POWER

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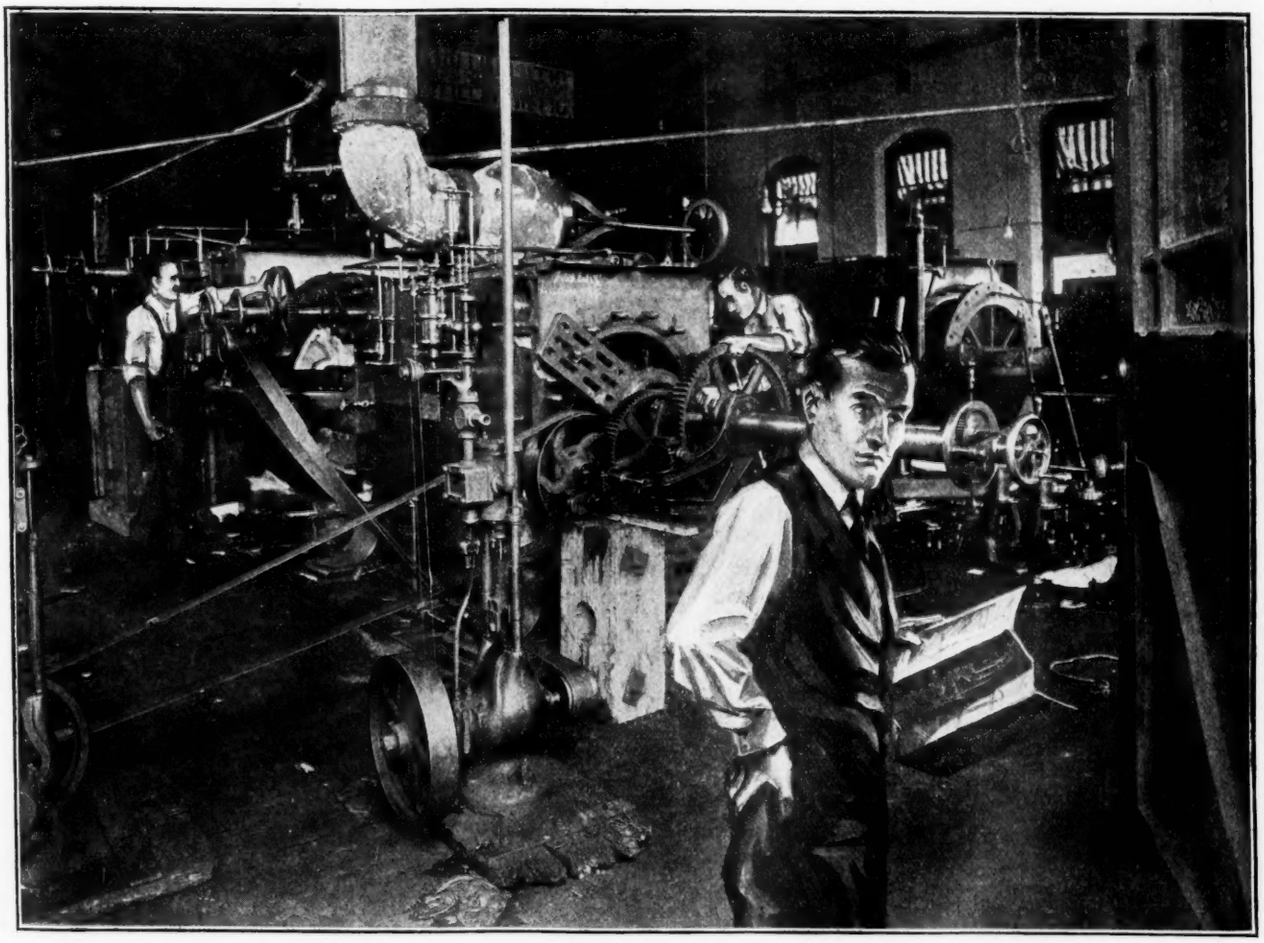
The Engineer's Vacation Soliloquy



"HARD luck, old man, hard luck! Here's the works shut down for stock taking. All the boys gone to the beach, mountains, fishing, swimming or just loafing about doing nothing, and I'm here getting my engines and boilers in shape for another year's run. No vacation for me.

"I wonder what a vacation is like? Let's see, it's nineteen years since I started engineering, and I've never had a day off since. I believe I did have vacations when I went to school, but that is a long, long time ago. I remember I used to feel fit as a fiddle when the new term began. I wonder if a fellow wouldn't feel more up to the minute if he got a week or two each summer when he could forget all about the responsibility of his plant and could feel and act like a kid again.

"Let's see, the president of the company is off on an automobile run, the vice-president has gone on a fishing trip down in Maine, and the general manager is out on his farm looking over his fancy stock. I don't know where the superintendent is, but he's not here, at least not so you would notice it. The fact is, old man, the bunch is all gone somewhere for a good time.

"Well, I suppose the thing to do is to get all my repair work done and everything ready for starting up Monday morning. That's the job, old man, and no mistake—and some job too—reboring cylinders and valve seats, lining boiler furnaces and a hundred other things. But you'll do it, you'll do it.

"I hope the boys and their families are having a good time. I wonder if any of them give thought of how I have to stay here getting things ready to run so that they will have work when their vacation is over. I wonder if the president has ever considered that if I fall down on the repair work it will take good American dollars out of the profits of the mill. I wonder if he has ever thought that I might enjoy myself and be benefited as well, if I had a few days off in which to just walk in the fields or lie down in the cool shade of a great oak tree somewhere, with nothing to do but rest.

"Look here, old man, this day dreaming won't do! Get busy, for there is no vacation for you! But if you ever do get a position where you control the vacation days of your fellow man, don't forget the years when you wanted a few days to do as you pleased and couldn't get them."

Contributed by George E. Perkins

Boiler House as Stack Foundation

By L. C. HUFF*

Four-story steel and concrete building housing eight water-tube boilers, used as foundation for large steel stack. Novel supports and bracing to withstand wind pressure.

THE large steel smoke-stack recently erected at the St. Charles Street heating station of the Union Electric Light and Power Co., St. Louis, Mo., is of special design and construction and is considered to be a novel piece of engineering. The stack, shown in Fig. 1, is 12 ft. diameter and has a height of 262 ft. above the sidewalk level. It is made of steel plate varying in thickness from $\frac{3}{8}$ in. for the bottom sections to $\frac{7}{16}$ in. for the top sections. The extreme height was necessary on account of a city ordinance requiring that a smoke-stack having an area of over 380 sq.in., or 22 in. diameter, if a round stack, must be carried to a height of 12 ft. above the highest building within a radius of 200 ft. As this stack came within 200 ft. of the Hotel Statler, Fig. 1, which is 250 ft. high, a height of 262 ft. was necessary. In most boiler plants there is nearly always sufficient space for the smoke-stack to permit carrying the foundation well down into the earth, but in the present case it was quite the opposite. The plot of property owned by the company measured approximately 92x94 ft., and on this was to be erected a building housing eight 518-horsepower water-tube boilers. When the eight boilers were laid out on the property, there was no available floor space left on which to build a stack without obstructing the passageways in the rear of the boilers or between them if it were placed there. It was then decided to place the stack entirely overhead, and it was located at the end of the aisle between the two batteries of boilers, this being the most central location without interfering with the coal bunker and traveling conveyor overhead.

FIG. 1. STEEL STACK FOR ST. CHARLES HEATING STATION, ST. LOUIS

The base of the stack is at the second-floor level and is anchored to the floor steel by means of eight "shoes" securely fastened to the stack. These shoes are set between shear plates riveted to large steel girders, as shown in Fig. 2. This is known as the lower support. The flue connections from the boilers enter the stack just below this point. It was necessary to erect another support to take the side thrust due to wind pressure on the stack. It is 25 ft. above the lower support. The greater the distance between these two supports the less strain they would be required to take, but the dimension was established at 25 ft., allowing two stories, each of 12-ft. 6-in. floor height between them, and bringing the upper support to the fourth-floor level. This support is constructed of heavy steel girders laid horizontally and provided with shearing plates riveted to their flanges, forming a slot into which fits a cast-steel thrust plate riveted to the side of the stack, as shown in Fig. 3. This allows a sliding joint between the thrust plate on the stack and the steel supports, which cares for the vertical expansion in the stack due to the hot gases. The most interesting feature about this support is the method of transmitting the strain, due to the wind pressure, from the stack proper into the supports. This is accomplished by the cast-steel thrust plates pressing against the sides of the slots into which they fit. Assuming a high wind blowing toward the north, the strains would be transmitted from the stack equally through the thrust plates on the east and west sides of the stack into the steel girders instead of at the north side. There is no buckling effect on the stack, as it is not allowed to rest against the north support, but is gripped firmly and held in place by the shoes on each side. From the upper and lower supports the stresses are carried through a series of "X" bracing down into the footings under the building columns. The usual method of designing a stack is to provide at its base a block of concrete of sufficient size and weight to resist the overturning moments caused by the high winds, and to keep it in an upright position. In the present stack the same principles have been observed but the

*Chief Draftsman Union Electric Light & Power Co.

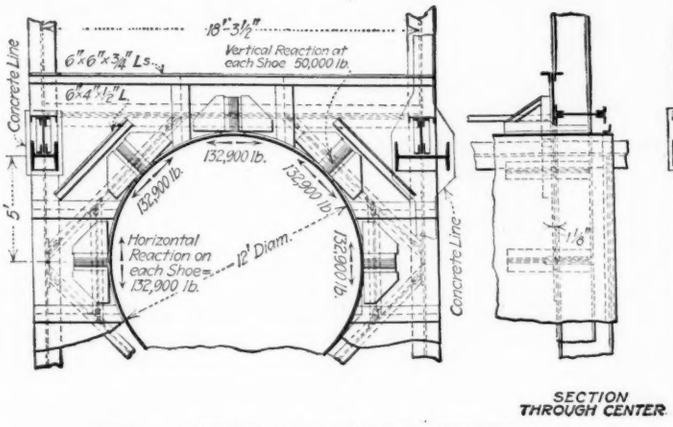


FIG. 2. DETAILS OF LOWER SUPPORT

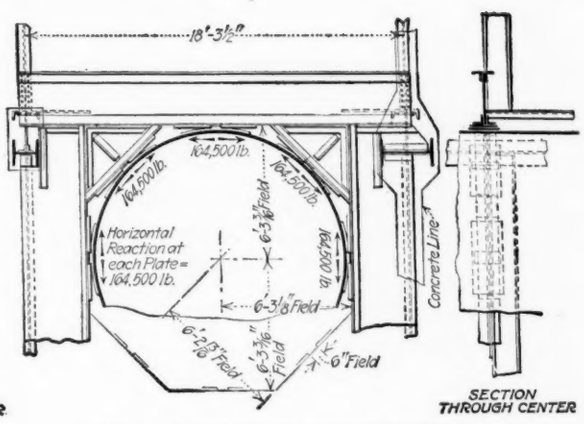


FIG. 3. LAYOUT OF UPPER SUPPORT

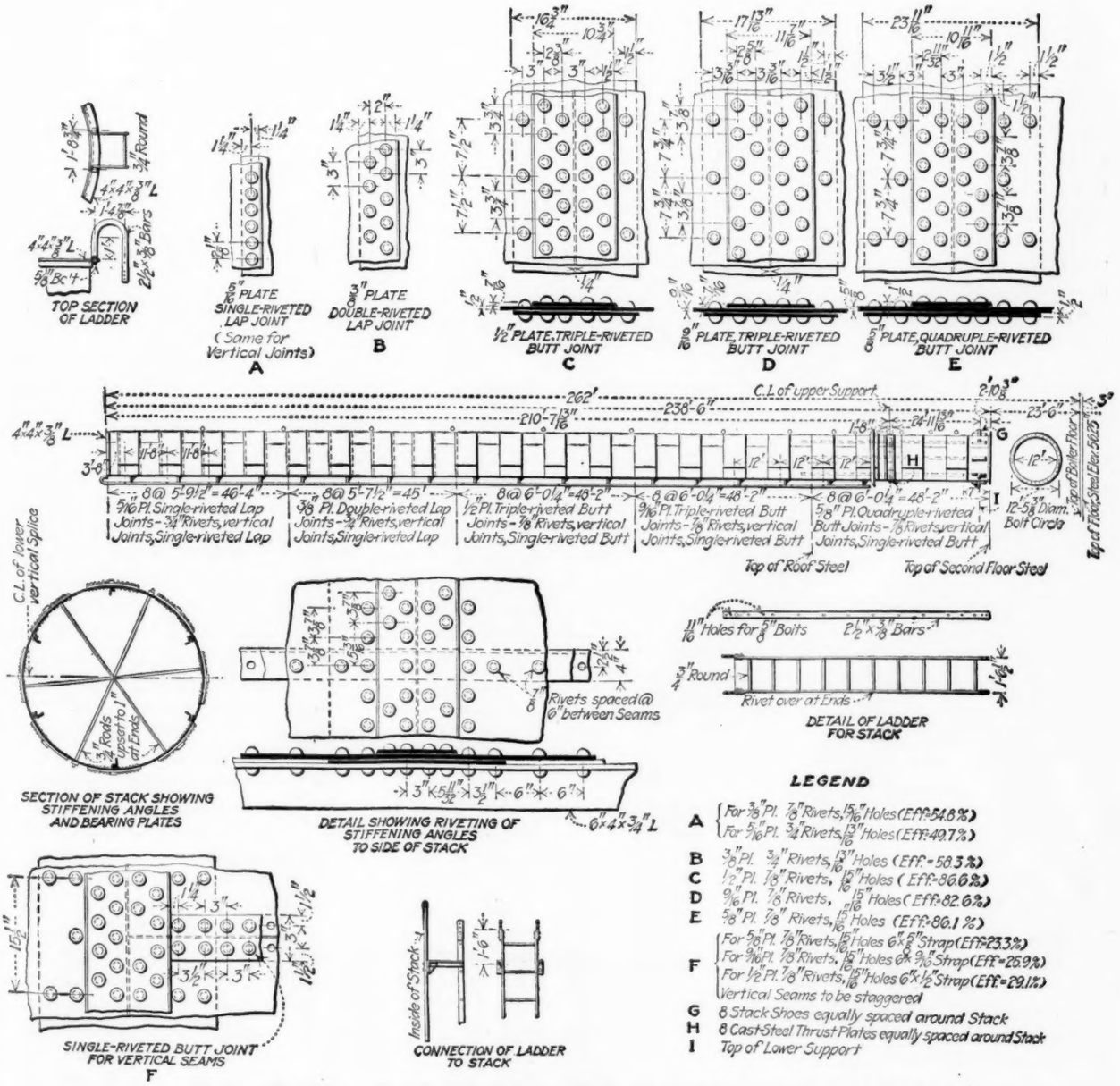

TOP SECTION OF LADDER
5/16" PLATE SINGLE-RIVETED LAP JOINT (Same for Vertical Joints)
A
3/16" PLATE DOUBLE-RIVETED LAP JOINT
B
½" PLATE, TRIPLE-RIVETED BUTT JOINT
C
9/16" PLATE, TRIPLE-RIVETED BUTT JOINT
D
5/8" PLATE, QUADRUPLE-RIVETED BUTT JOINT
E
C.L. of upper Support
262'
238'-6"
210'-7 13/16"
24'-11 15/16"
23'-6"
12'-5⅞" Diam. Bolt Circle
Top of Roof Steel
Top of Second Floor Steel
Top of Boiler Floor
8@ 5'-9½" = 46'-4"
9/16 Pl. Single-riveted Lap Joints - ¾" Rivets, vertical Joints, Single-riveted Lap
8@ 5'-7½" = 45'
⅜ Pl. Double-riveted Lap Joints - ¾" Rivets, vertical Joints, Single-riveted Lap
8@ 6'-0¼" = 48'-2"
½ Pl. Triple-riveted Butt Joints - ⅞" Rivets, vertical Joints, Single-riveted Butt
8@ 6'-0¼" = 48'-2"
9/16 Pl. Triple-riveted Butt Joints - ⅞" Rivets, vertical Joints, Single-riveted Butt
8@ 6'-0¼" = 48'-2"
⅝" Pl. Quadruple-riveted Butt Joints - ⅞" Rivets, vertical Joints, Single-riveted Butt
C.L. of lower vertical Splice
Rods upset to 1" at Ends
SECTION OF STACK SHOWING STIFFENING ANGLES AND BEARING PLATES
Rivets spaced @ 6" between Seams
DETAIL SHOWING RIVETING OF STIFFENING ANGLES TO SIDE OF STACK
11/16" Holes for ⅝" Bolts
2½" × ⅜" Bars
¾" Round
Rivet over at Ends
DETAIL OF LADDER FOR STACK
SINGLE-RIVETED BUTT JOINT FOR VERTICAL SEAMS
F
Inside of Stack
CONNECTION OF LADDER TO STACK
LEGEND
A For ⅜" Pl. ⅞" Rivets, 15/16" Holes (Eff. = 54.8%)
A For 5/16" Pl. ¾" Rivets, 13/16" Holes (Eff. = 49.7%)
B ⅜" Pl. ¾" Rivets, 13/16" Holes (Eff. = 58.3%)
C ½" Pl. ⅞" Rivets, 15/16" Holes (Eff. = 86.6%)
D 9/16" Pl. ⅞" Rivets, 15/16" Holes (Eff. = 82.6%)
E ⅝" Pl. ⅞" Rivets, 15/16" Holes (Eff. = 80.1%)
F For ⅝" Pl. ⅞" Rivets, 15/16" Holes 6" × ⅝" Strap (Eff. = 23.3%)
F For 9/16" Pl. ⅞" Rivets, 15/16" Holes 6" × 9/16" Strap (Eff. = 25.9%)
F For ½" Pl. ⅞" Rivets, 15/16" Holes 6" × ½" Strap (Eff. = 29.1%)
Vertical Seams to be staggered
G 8 Stack Shoes equally spaced around Stack
H 8 Cast-Steel Thrust Plates equally spaced around Stack
I Top of Lower Support

FIG. 4. DETAILS OF STACK PROPER, SHOWING RIVETED-JOINT CONSTRUCTION

application differs. The whole building is considered a block of concrete hollowed out on the inside, to which the strains are transmitted by the "X" bracing; the dead weight of the structure holds down the columns. Thus the steel and concrete materials used in the building serve two purposes—one to support the floors and roof, and the other to form a stack foundation. This bracing is clearly shown in Fig. 5.

To determine the strains in the "X" bracing, and the loads on the columns and footings under the varying conditions of loading, required a great deal of thought and study, and the preparation of elaborate strain diagrams. The building columns were designed to carry six stories in all, and this extra weight had to be cared for in the design of the columns and footings, to keep within the safe bearing value of the soil. On the other hand, as only four stories were to

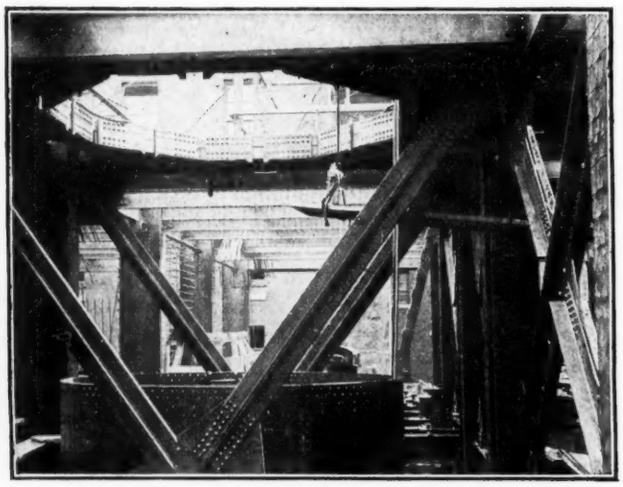


FIG. 5. VIEW SHOWING "X" BRACING

be erected at this time, it was necessary to provide sufficient dead weight in these four stories, omitting any live loads, to counteract the upward pull on the columns due to the wind load on the stack. The wind had to be considered blowing in any one of the four directions and also at an angle of 45 deg. The maximum stress or load created by any one of these conditions, or combinations thereof, was used in designing the members. The stress diagrams from this stack, when laid out, required three 24 x 48-in. sheets.

Details of the stack proper are shown in Fig. 4 The joints in the lower section, or in the $\frac{5}{8}$-in. plate material, are of the quadruple-riveted butt type, and have an efficiency of 93½ per cent. The section of the stack passing through the upper support is reinforced with vertical angles riveted on the inside of the stack, as the maximum bending moment occurs at this point. Heavy girth angles are also riveted to the outer circumference near this support to help it retain its cylindrical shape.

The wind pressure assumed in designing the stack was 50 lb. per sq.ft. over one-half of the diametral plane, which corresponds closely to a wind velocity of 100 miles per hour. Another $\frac{1}{16}$ in. was added to the thickness of the plates to allow for corrosion and deterioration, as the stack has no lining of firebrick or tile. The safe fiber stress used in designing the stack was 15,000 lb. per sq.in. and 9500 lb. per sq.in. for rivets in shear. For all cross-bracing the fiber stress allowed was 12,000 lb. per sq.in. and 10,000 lb. per sq.in. for rivets in shear.

The stack was designed by the engineering department of the company and was fabricated and erected by the John Nooter Boiler Works, of St. Louis. Record time was made in letting the contract, in placing the order for the steel stack plates, and also for the structural steel used in the building proper. Authority was given to build this heating station on Jan. 26, 1917. The contract was closed for the building steel on Feb. 6, and cutting lengths of the beams and columns were sent to the mills on Feb. 7. An order for the stack plates, amounting to approximately 132 tons of material, was sent to the steel mill about Feb. 1. The price of steel was rapidly soaring upward at this time, and it was necessary that material be ordered at the earliest possible date. There were 33,000 rivets used in the construction, and these rivets alone weighed 25,000 lb. The punchings—that is, the metal punched from the rivet holes in the plate—amounted to 8250 lb., or slightly over four tons. Erection of the stack began on July 1, and the work was completed Oct. 27, requiring about four months' time.

During one of the recent severe storms the writer visited this stack when the wind velocity was close to 100 miles per hour. There was no noticeable movement in the stack at the upper or lower support, these points being very rigid. The upper section was weaving slightly owing to the flexibility of the steel.

Injury Through Exposed Cogwheels

The California Supreme Court has affirmed judgment in favor of an engineer operating a pumping plant, on account of injury sustained through a rag held in his hand catching in exposed gearing connected with the pump, just as he had completed wiping part of the machinery. (Scherer vs. Danziger, 173 Pacific Reporter, 85.)

Finding that defendant's liability was sufficiently established on other grounds, the court did not pass upon a question raised as to whether defendant's failure to furnish plaintiff with cotton waste, instead of a rag, for use in wiping the machinery could be regarded as an actionable cause contributing to the accident.

It was found by the court that liability sufficiently rested upon the action of the defendant's foreman in insisting that a cover that had previously covered the cogwheel be removed. This is held to have been a violation of the employer's legal duty to furnish plaintiff with a reasonably safe place of work. And, in view of the provisions of the California Employers' Liability Act, it is further decided that the plaintiff could not be deemed to have assumed the risk of the injury because he knew that the gearing was unguarded.

Under this act contributory negligence of an employee does not preclude recovery for resulting injury, if it was slight as compared with the negligence of the employer. Applying this phase of the law, the court holds that the jury was warranted in finding that the particular manner in which plaintiff accidentally permitted the rag to come in contact with the gearing was only slightly negligence, as compared with the greater negligence of the employer in leaving the gearing unguarded.

Visits of Inspector Brown—XXXI

By J. E. TERMAN

The Chief and Brown discuss economizers. The former gives the reason for the existence of economizers, explains their function, describes the counter-current principle often made use of in their operation, and tells of the gain in efficiency by their use.

WHEN the Chief came into his office one morning, he found on his desk a note from Brown, reading as follows:

Dear Chief: What is an economizer, and why?

BROWN.

"Well," said the Chief to himself, "I suppose Brown has eaten his peck of soot inspecting an economizer lately, and wants all of them consigned to the lower regions." Using the reverse side of the paper on which Brown had written, the Chief wrote as follows:

Dear Brown: An economizer is a push-nipple cast-iron boiler, usually operated at very high pressures. Come into my office when you have time and we will talk it over.

THE CHIEF.

As the Chief laid this note on Brown's desk, he said to Inspector Jones, who was sitting on the other side of the desk: "Well, I guess this will hold Brown for a while," and he then left the office.

When Brown came in and read the Chief's note, he had a hearty laugh, but thought he scented an interesting talk in the last sentence and resolved to take up the Chief's offer at the first opportunity. The next day, having finished his inspection work early in the afternoon, he presented himself to the Chief and suggested that he would like to talk over those "high-pressure push-nipple cast-iron boilers," if the Chief had time. "I will take time, Brown," was the reply, "for I don't know of anything that should be of more interest to an inspector, or one that it is more necessary for an inspector to know about in the interest of our company and its patrons, than economizers. You know from our company's records that we have an awful lot of money invested in economizer accidents. If you inspectors don't keep your eyes open and your think tanks clear, we are liable to have a lot more money invested in the same way. You know, Brown, an explosion is a very good 'ad' for the boiler-insurance business in general, but it is not worth the price to the company footing the bill. We believe in advertising, but we want to do it in a modest way. To begin our discussion of economizers, we will first have something to say about the 'why,' as you express it. There are excellent and sufficient reasons for the existence of economizers. You appreciate the good that is gotten out of feed-water heaters."

"Why yes, Chief, I believe I understand some of the benefits to be got by heating the feed-water before it goes into the boiler, by the exhaust steam that has done its work in the engine."

"You can then understand, Brown, that the exhaust-steam feed-water heater is a kind of economizer placed on the end of the steam-using apparatus in a plant, to trap some of the B.t.u.'s that slip by the engines or other steam-using equipment. What we know as an economizer is an equipment placed on the end of the steam-generating apparatus to catch some of the B.t.u.'s that refuse to pass through the boiler surfaces and aid in the evaporation of water into steam. In other words, an economizer is merely an extension of the boiler placed in a separate setting.

Why the Economizer Has a Separate Setting

"You will naturally ask, Why the separate setting? Well, as far as economy goes, the boiler and the economizer should be in the same setting. In fact, the economizer should be in every way a part of the boiler except for the circulation of the water. However, owing to the fact that one economizer is usually provided to serve a number of boilers and to make both the economizer and the boilers accessible, it is usual to have them independent of each other.

"Now the reason that the economizer extracts heat units that the boiler passes up, is because of the temperatures that have to be handled in the boiler. If a boiler is operating at 175 lb. pressure, the temperature of the water in it will be about 377 deg. F. If the circulation of the water in the boiler is what it should be, every portion of the boiler structure will be within a few degrees of the temperature of the water. If the circulation in the boiler is not what it should be, you have had enough experience in the inspection of boilers, Brown, to know what will happen in the line of pitting and corrosion in those parts where the circulation is sluggish. To get a transfer of heat, from the gases to the water in the boiler, of sufficient rapidity to make the use of the boiler surfaces worth while, there should be a minimum difference of temperature between the gases and the water of about 180 deg. Therefore, in the boiler under consideration, the exit temperature of the flue gases would have to be at least 557 deg. F. Now if gases at this temperature should be brought into contact with heating surfaces wetted by water direct from the hotwell at, say, a temperature of 120 deg., there would be a rate of heat transfer that would be worth while. This is the function of an economizer," continued the Chief, "to provide a meeting place for the gases that have become too cold to be of service in contact with the boiler surface, and the feed water that has not yet reached boiler temperature. The counter-current principle is usually made use of in economizer operation, as an aid in reducing the gases to the lowest temperature practicable before they are voided to the stack."

The Chief Explains the Counter-Current Principle

"What is the counter-current principle, Chief? I have heard that expression used in connection with boiler work, but I have never understood just what it meant," said Brown.

"That is only a convenient way of saying that the gases are to flow through the economizer in the opposite direction from the water; that is, the water is to enter the end of the economizer next to the stack. In this

way the coldest water meets the coolest gas, which permits the lowering of the temperature of the exit gases to a minimum.

"I want to show you, Brown, by a few calculations, what an economizer may be expected to do. If we should take an economizer already installed, and find the entrance and exit temperatures of the water passing through it and also the weight of the water that flowed through it in a given length of time, it would be an easy matter to find just how many heat units were supplied to the water by the waste gases flowing through the economizer. But I want to calculate this from the weight and temperature of the gases, because I will want to refer you to the result for another purpose later on. If there is 180 deg. difference between the temperature of the gases escaping from the economizer and the water as it enters, and water is supplied to the economizer at 120 deg., the exit gases from the economizer could have a temperature of 300 deg. and still have a difference of 180 deg. between the gas and the water.

"We will assume that the boiler pressure is 150 lb. and that the gases delivered to the economizer are at a temperature of 550 deg.; that is, a drop in the temperature of the gases passing through the economizer of 250 deg. Again, suppose that all the water passed through the economizer was used to feed the boilers which supplied the waste gases, and that these boilers were operating at an efficiency of 65 per cent. and were using fuel that contained 13,500 B.t.u. per lb. This would mean that for every pound of fuel burned, $13,500 \times 0.65 = 8775$ B.t.u. would be absorbed by the water in the boiler. The weight of flue gases furnished to the economizer per pound of fuel burned under the boilers would be about 22 lb. This weight of flue gases would represent the use of about 21 lb. of air per pound of fuel burned. The specific heat of flue gas is about 0.24; that is, 1 lb. of such gas would give up 0.24 B.t.u. in dropping 1 deg. in temperature.

B.T.U. Available for Heating the Water

"Since we have assumed that the gas in passing through this economizer is to drop 250 deg. and that 22 lb. of gas will be the result of the combustion of a pound of fuel, there would be made available for the purpose of heating water in the economizer, $250 \times 0.24 \times 22 = 1320$ B.t.u., for each pound of fuel burned. This, of course, does not consider any economizer losses such as radiation, air leakage, etc., but assumes that all the heat is absorbed by the water in the economizer. As an aid in making the calculations, we will draw up a schedule of the data we have assumed," said the Chief.

Temperature of the water entering the economizer, 120 deg. F.

Temperature of the exit gases from the economizer, 300 deg. F.

Drop in temperature of the gases passing through the economizer, 250 deg. F.

Weight of gases supplied per pound of fuel burned, 22 lb.

Specific heat of the gases, 0.24.

Efficiency of the boilers alone, that is, without considering the economizer, 0.65 per cent.

Amount of heat contained in a pound of fuel, 13,500 B.t.u.

Steam pressure at which boilers are operated, 150 lb.

Heat absorbed by the boilers for each pound of fuel burned, $13,500 \times 0.65 = 8775$ B.t.u.

"The amount of heat put into the water by the economizer would be 1320 B.t.u., as I have just shown you," said the Chief. "Therefore, $8775 + 1320$, or 10,095, out of the total of 13,500 B.t.u. in a pound of coal would be made available for the evaporation of water. The efficiency under such conditions would be $\frac{10,095}{13,500}$, or 74.7 per cent., a gain of nearly 10 per cent. over the efficiency when the boiler was used alone.

To Find the Temperature of the Water

"Now I am going to tell you how to find the temperature of the water as it comes from the economizer, from these data. By looking at a steam table, we find that the amount of heat that must be applied to a pound of water at a temperature of 120 deg. F., to make it into steam at a gage pressure of 150 lb., is about 1105 B.t.u. Therefore, by dividing the total heat available by this amount, we have, $\frac{10,095}{1105}$, or 9.13 lb. of water evaporated per pound of coal burned. Since the heat imparted to the water by the economizer, per pound of coal burned, is 1320 B.t.u., and this heat is used to raise the temperature of 9.13 lb. of water from 120 deg. F., the exit temperature of the water from the economizer will be about $120 + \frac{1320}{9.13}$, or 264.5 deg. I want you to pay particular attention to this calculation, Brown, for I will refer to it again in a way that will show you that it is of great importance to our business of insuring economizers. If you are satisfied with my explanation of the 'why' for economizers, we may proceed to discuss 'what an economizer is.'"

"Gee! I guess it's too late to start on that, Chief. You will be wanting to go home. I'll come in tomorrow afternoon to hear about what an economizer is," said Brown.

Explosion of Boiler Tube

Judgment for damages based on injury to an employee in a steam-power plant when a boiler tube exploded has been affirmed by the Maryland Court of Appeals in the case of McKeon vs. Capitol Traction Co., 103 Atlantic Reporter, 314. The judgment is based on a conclusion that enough evidence was adduced at the trial to support the jury's finding that defendant was guilty of negligence in failing to discover and remedy the precise defect which resulted in the accident, especially since there was evidence tending to show that the company's attention had been drawn to a swelling in the tube.

On one phase of the case the court held that if the company's attention had been called to the condition of the tube, it could not justify failure to discover the particular defect resulting in the explosion on the ground that it had adopted a usual method of inspection. "The defendant may have adopted the usual method of inspecting," said the court, "yet when notified of a defect in the boiler it was its further duty to locate the defect and, if possible, to correct it."

The Electrical Study Course—Counter-Electromotive Force of Motors

Explaining what the counter-electromotive force of a motor is, and how it automatically controls the adjustment of the current to the load imposed on the motor. Also how speed control is dependent upon it.

IN THE previous lesson it was found that generators can be used as motors. Having given an armature situated in a magnetic field as in a dynamo-electric machine, the machine becomes a generator when we compel the armature to revolve by applying mechanical power to it, whereas when we supply electrical power to it, it becomes a motor and furnishes mechanical power. In both cases we have the condition that a multitude of conductors are carrying currents and that they are moving across a magnetic field. The question then arises, what is the difference which causes the machine to act as a generator in one case and as a motor in the other if the conditions in both cases are the same? Briefly stated, it is that the two actions are opposite to each other and that in one case the generator action is greater than the motor action, and in the other the motor action exceeds the generator

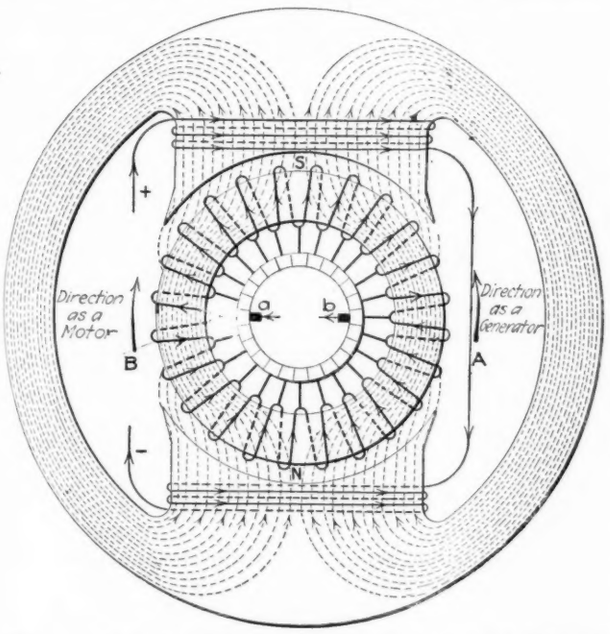


FIG. 1. SHOWING SIMULTANEOUS MOTOR AND GENERATOR ACTIONS IN AN ARMATURE

action. That is, both actions are present whether the machine be operating as a generator or as a motor, but the one is greater than the other, depending on whether it is being used to convert mechanical into electrical energy, or vice versa.

Let us consider how these actions combine to give the results obtained. Suppose we have an armature situated in a magnetic field, as in Fig. 1, and that the direction of the current in the armature winding and the direction of the flux is as indicated thereon. Unless we knew the direction in which the armature was revolving, it would be impossible to say whether it was being driven as a generator or was running as a motor. It might be operating as either. As a generator it would have to be driven in the direction of the arrow *A* if the current is to be in the direction

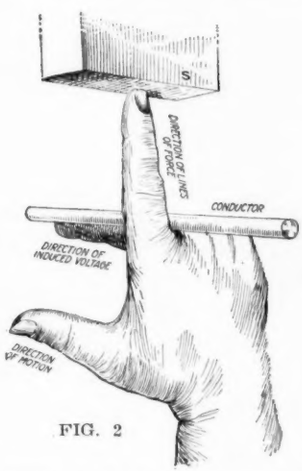


FIG. 2

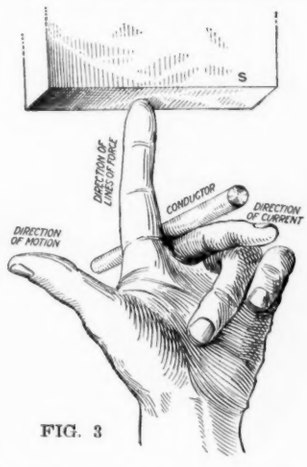


FIG. 3

FIGS. 2 AND 3. RIGHT- AND LEFT-HAND RULES TO DETERMINE DIRECTION OF ROTATION OF GENERATORS AND MOTORS

shown, as may be determined from the right-hand rule illustrated in Fig. 2. As a motor it would revolve in the opposite direction if the direction of the current was made the same, as shown in the left-hand rule illustrated in Fig. 3. It is therefore apparent that, as previously stated, the motor and generator actions are always opposed.

Suppose the machine to be operating as a generator. When it has a load connected to it, the current passing through the armature wants to make all the conductors of the winding move across the field in the direction *B*, and in order that this force shall not reduce the speed at which the engine or other prime mover is shoving them in the direction *A*, the prime mover must exert a pull equal to the drag of the conductors.

Suppose, now, that the machine is operating as a motor. It will of course be revolving in the direction *B*. When the armature conductors move in this direction through the field they have an em.f. induced in them in such a direction as would make brush *b* positive and brush *a* negative. That is, an em.f. would be generated and it would be in opposition to the applied voltage, illustrating in another way how the motor and generator actions oppose each other. The em.f. which is generated by the conductors of the motor in opposition to the applied voltage is called the counter-electromotive force of the motor; it is abbreviated counter-em.f. or c.em.f. and is also often referred to as back-em.f., the words counter and back indicating that it is in opposition. It is of considerable importance to gain a correct understanding of what the counter-em.f. of a motor is, as the entire

operation of the machine hinges on the fact that such an em.f. is generated.

Since the armature of the motor generates an em.f. in opposition to the voltage applied to it, the current which can flow through it is equal to the difference between the applied voltage and the counter-em.f. divided by the resistance of the armature. That is,

$$\frac{\textit{Applied voltage} - \textit{counter-em.f.}}{\textit{armature resistance}} = \textit{armature current}$$

Stated another way, it means that the difference between the applied voltage and the counter-em.f. is equal to the voltage drop over the armature resistance, which is, of course, equal to the resistance of the armature multiplied by the current flowing through it; that is, the applied voltage minus the counter-em.f., is equal to the armature resistance times the armature current. The counter-em.f. of a motor will always be less than the applied voltage, for if the two were ever to become equal to each other, there would be no difference and no current could flow, but then the armature could not continue running since its motion depends upon the fact that we have current passing through conductors situated in a magnetic field. The moment the armature began to slow down, a very interesting action would take place, as shown in the following:

In the study of generators it was found that the em.f. generated by conductors moving across a magnetic field is proportional to the rate at which the lines of force are cut by the conductors. If the speed is decreased while the field strength is kept constant, the em.f. will be decreased because the total number of lines of force passed in one second will be less than before. It follows that the instant the armature of the motor slows down, the em.f. which its conductors generate will be decreased. That is, its counter-em.f. would immediately become less than the applied voltage, in consequence of which a current would flow, and as soon as the current became great enough to keep the armature revolving, there would be no further reduction in speed; the armature would continue to revolve at whatever speed it had dropped to. If the motor is running idle, only very little current will be required to keep it running, merely enough to overcome friction and other internal losses, which will be discussed somewhat farther on. The applied voltage multiplied by the current flowing will give the watts used up in the motor to overcome its losses. Were a load now to be placed on the motor it would of course tend to retard its motion. The speed would again begin to drop and would continue to do so until the counter-em.f. had been reduced to such a value as would allow sufficient current to flow to overcome the load imposed on the motor. The product of the voltage and current would now be the watts required to drive the load plus the internal losses of the motor.

Provided the supply voltage remained constant we would find a certain definite speed for each load, and the greater the load the lower the speed. The amount of change in speed for change in load differs greatly in the different types of motors. The shunt motor suffers the least change, the series motor the most, the compound motor being in between the two. The amount of change and what determines its magnitude will be dealt with subsequently. It is well to note here that the difference between the applied voltage and the counter-em.f. is never very great. An example will illustrate the reason for this. If a 5-hp. 110-volt motor whose armature resistance is 0.1 ohm is carrying full load, it would be delivering 5×746 watts, or 3730 watts. The current it would take would be the number of watts divided by the voltage, or $3730 \div 110$, which neglects the losses in the motor but approximates the correct value closely enough for our purpose and gives, roughly, 34 amperes. The voltage drop in the armature would be 34 amperes multiplied by 0.1 ohm, or 3.4 volts, which would be the difference between the applied voltage and the counter-em.f., and the value of the latter would therefore be 110 volts minus 3.4 volts, or 106.6 volts. In this case, the drop in voltage is only about 3 per cent. for full load. Any material decrease in the counter-em.f. would allow an enormous current to flow and would result in the operation of the safety devices protecting the motor and the circuit to which it is connected. For instance, if the counter-em.f. should drop to 80 volts, the difference between it and the applied voltage would be 110 volts minus 80 volts, or 30 volts, and the current taken by the armature would be this difference divided by the armature resistance, or 30 volts divided by 0.1 ohm, giving a current of 300 amperes, which is nine times the full-load current.

It has already been shown that the motor adjusts its counter-em.f. to meet whatever load is placed upon it and this is one of the most valuable properties it possesses. It inherently regulates the amount of current taken by itself to meet the load imposed upon it without the use of a governor or regulator of any kind, in which respect it differs widely from motors driven by any other power.

It has been said that the speed of a motor adjusts itself to the value at which the correct counter-em.f. for the particular load on it will be generated; that is, the counter-em.f. is the controlling factor in the automatic regulation of the motor. The counter-em.f., however, is affected by the strength of the magnetic field, which leads to a peculiar feature in the operation of the machine. Suppose a shunt motor, for example, to be revolving at a certain speed while driving a load. If the field strength were to be reduced, as it would be if we were to decrease the field current for any reason, then the counter-em.f. generated would drop in proportion. A drop in the counter-em.f., however, would cause the motor to take a greater current than that required by the load upon it, in consequence of which it would speed up in order to increase the load upon itself. Another way to look at it is that when the current increases, it causes a greater reaction between the armature conductors and the field flux, and the conductors are therefore made to move across the field at a greater speed. It should be remembered, however, that the field flux is less than it was, so that it would not be possible to state without further investigation whether there would be a greater force acting on the conductors, since the force depends on the strength of the field as well as on the current in the conductors. As a matter of fact, the percentage of increase in armature current far exceeds the percentage of decrease in flux, and the armature does speed up. Upon speeding up, the counter-em.f. again in-

creases, thereby decreasing the armature current until the point is reached at which the current flowing is again just sufficient to take care of the load. Since the load is being driven at a greater speed, it will require more power to drive it, and consequently, the new value of armature current will be somewhat higher than that previously observed.

It seems contradictory at first sight that the speed of a motor should increase when the field current is decreased, since it would make it appear that less energy is required to drive a motor at a high speed than at a low speed. But it must be remembered that the armature current increases, so that the total current taken by the machine, that is, the sum of the armature and field currents, actually increases for increase of speed.

When the field current is increased, the consequences are the converse of those described and the speed of the motor is reduced. As before, assume that while a shunt motor is running under a given set of conditions, the field current is increased. The counter-em.f. is thereby increased and the armature current consequently decreased. The motor then takes an amount of current insufficient to drive the load at the original speed and is consequently compelled to slow down. Upon doing so, the counter-em.f. decreases, allowing the armature current to increase. The speed will decrease until the armature current has attained a value sufficiently great to take care of the load. The new current will be somewhat less than that previously observed since the speed has been somewhat reduced.

The fact that the speed of a motor increases when the field current decreases and decreases when the field current increases, is an extremely important one and should be firmly fixed in mind. On it depends the chief method of control of variable speed motors, as will be shown in a following lesson.

The problem which was given for solution in the last lesson consisted of several parts. First, it was required to find the size of wire required to limit the line drop to 10 per cent. of the normal voltage. Since 120 volts is the normal voltage, the voltage drop in line would be 10 per cent. of 120 volts or $\frac{1}{10} \times 120 = 12$ volts. The resistance of the line would be the voltage drop in it divided by the current flowing through it. The current flowing would be the watts taken by the load divided by the voltage. The load consists of 2100 forty-watt lamps and would therefore be $2100 \times 40 = 84{,}000$ watts. Consequently the line current would be this number of watts divided by 120 volts, or $\frac{84{,}000}{120} = 700$ amperes. The resistance of the line would therefore be the voltage drop divided by this current, or $\frac{12}{700} = 0.01714$ ohm. There are two lines each $\frac{3}{4}$ mile long, making a total length of $\frac{3}{4}$ mile. Since there are 5280 ft. in a mile, the total length of wire in the line is $\frac{3}{4} \times 5280 = 3960$ ft. The resistance per thousand feet would be the total resistance of the line divided by its length in feet multiplied by one thousand, or $\frac{0.01714}{3960} \times 1000 = 0.004329$ ohm per thousand feet.

From the tables of resistance of copper wire it is found that a 2,000,000-cir.mil cable has a resistance of 0.005177 ohm per 1000 ft., which is greater than the resistance required. Since this is the largest cable in general use, it would be necessary to use two cables in multiple to meet the conditions. We could use one cable of 2,000,000 cir.mil and a smaller one of such size as to reduce the resistance to the value desired, but the more usual way would be to use two like cables of such size as would give the required resistance when placed in multiple. When two conductors of the same resistance are placed in multiple the combined resistance is one-half the resistance of either one, which is the same as saying that the resistance of either is twice their combined resistance. In the case of our problem the combined resistance is to be 0.004329 ohm per 1000 ft.; hence the resistance of each of the two conductors would be twice that value, or $2 \times 0.004329 = 0.008658$ ohm per 1000 ft. From the wire table we find that a 1,250,000-cir.mil cable has a resistance of 0.008282 ohm per 1000 ft. and this would therefore be the required size. The total resistance would be slightly less than that specified, and we might try whether it would be possible to use one 1,250,000-cir.mil and one 1,000,000-cir.mil cable. The resistance of the latter size is 0.010353 ohm per 1000 ft. and the combined resistance of the two would be their product divided by their sum, or $\frac{0.008282 \times 0.010353}{0.008282 + 0.010353} = 0.004601$ ohm per 1000 ft., which proves to be too great; consequently two 1,250,000-cir.mil cables would be used.

As already found, the generator would be delivering 84,000 watts to the lamps, which is equal to 84 kw. Since the capacity of the generator is 1000 kw., the lamp load would be $\frac{84}{1000}$ of its capacity, or 8.4 per cent.

The voltage at the generator would be the voltage at the lamps plus the volts drop in line, or $120 + 12 = 132$ volts. The watts lost in the line would be equal to the line current, 700 amperes, multiplied by the volts drop in line, 12 volts, which gives $700 \times 12 = 8400$ watts loss.

The load supplied has been found to be 84,000 watts; the line loss is 8400 watts. To find what percentage of load supplied the line loss amounts to, we divide the line loss by the load and multiply by 100, which gives $\frac{8400}{84{,}000} \times 100 = 10$ per cent.

A 5-hp. 115-volt shunt motor has an armature resistance of 0.25 ohm. Its efficiency is 85 per cent. at full load and 70 per cent. at half load. What counter-em.f. would be generated at those loads? What would be the watts loss in each case due to resistance of armature? If the counter-em.f. were to be 108 volts, what current would the motor be taking?

Methods of Finding Starting Torque

BY L. L. LOOMER

A TEST was made to ascertain the starting torque of a cross-compound horizontal engine in a rolling mill. The crankshaft of the engine was geared to a jackshaft that in turn was gear-connected to a number of pairs of rolls.

Continuous indicator diagrams were taken for a few revolutions, to find the steam pressure in the high-pres-

sure cylinder at the start. The first two of these diagrams are shown in Fig. 1, at *A* and *B*, respectively. It will be observed that diagram *A* is shorter than diagram *B*. This is due to the fact that the piston of the high-pressure cylinder was at some distance from the head at the moment steam was turned on. The length

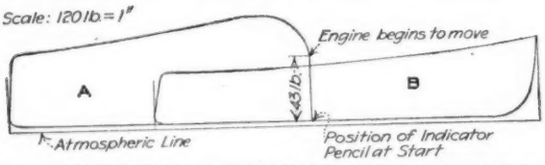


FIG 1. CONTINUOUS INDICATOR DIAGRAMS TAKEN AT STARTING

of the diagram *B*, on the other hand, represents a full stroke of the piston.

The engine was 26 by 60 in., with a high-pressure piston rod 3½ in. in diameter and a connecting-rod 15 ft. long. The engine ran under, and at the start the crank of the high-pressure cylinder was in the upper left-hand quadrant, as indicated by *OA*, Fig. 2. The exact position of the crank with respect to the stroke line *BC* was not observed, but was determined graphically. Two straight lines are drawn, as in Fig. 3, so as to form an acute angle *A*, and the distances *AB* and *AC* are laid off equal to the lengths of diagrams *A* and *B*, Fig. 1, respectively. The distance *AD* is made equal to the stroke *BC*, Fig. 2. Then *B* and *C* are joined by a straight line, and from *D* a line is drawn parallel to *BC* until it cuts *AB* at *E*. As the triangles *ABC* and *AED* are similar, the distance *AE* represents the part of stroke yet uncompleted by the high-pressure piston.

In Fig. 2, *CD* is laid off equal to *AE*, Fig. 3, and then the point *D*, Fig. 2, represents the position of the high-pressure piston at the instant the engine starts. To determine the crank position, *DE* is laid off to represent the length of the connecting-rod, to the same scale as *BC*, which represents the stroke. With *E* as a center and a radius equal to *DE*, an arc is drawn to cut the semicircle at *A*, and *OA* is then the crank position at the start.

By scaling diagram *A*, Fig. 1, it is found that a pressure of 43 lb. per sq.in. exists in the crank end of the cylinder at the instant the engine begins to move. The area of piston subjected to this pressure is 519 sq.in., and so the total pull on the piston rod is 43 × 519 = 22,317 pounds.

In Fig. 2, drop a perpendicular from *A* to the stroke line at *F*. Then, if the length *FE* is allowed to represent the pull of 22,317 lb. on the piston rod, the length *AE* will represent, to the same scale, the pull in the connecting-rod. Thus, the pull in the connecting-rod is 22,317 times the ratio of *AE* to *FE*, or approximately 22,620 pounds.

The length *OA*, Fig. 2, represents 2.5 ft., or the length of the crank. To the same scale, the perpendicular distance *OG* from the point *O* to the center line

FIG. 3

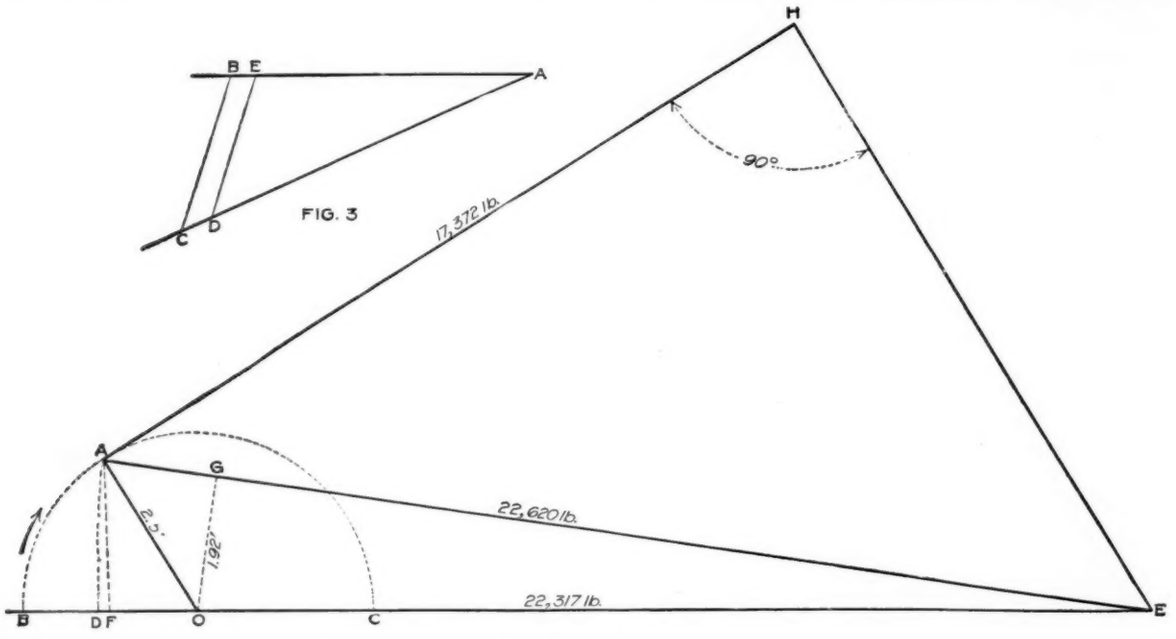


FIG. 2

FIGS. 2 AND 3. DIAGRAMS FOR FINDING CRANK POSITION AND TORQUE

of the connecting-rod represents 1.92 ft. Consequently, the torque of the engine at the start is

$$22{,}620 \times 1.92 = 43{,}430 \text{ lb.-ft.}$$

A check on these figures may be obtained by finding the tangential pressure at the crankpin. The line *EH* is drawn from *E* parallel to *OA*, and *AH* is drawn at right angles to *OA*. The length of *AH* then represents the tangential pressure to the same scale as *AE* represents the connecting-rod pull. Thus, the tangential pressure is 22,620 times the ratio of *AH* to *AE*, or approximately 17,372 lb. The torque is the product of the tangential pressure and the length of the crank, or

$$17{,}372 \times 2.5 = 43{,}430 \text{ lb.-ft.}$$

which agrees with the value previously found.

The foregoing calculations neglect the friction of the engine, which may amount to as much as 20 per cent. If the friction is taken as 20 per cent., the actual torque will be only 80 per cent. of the value calculated, or

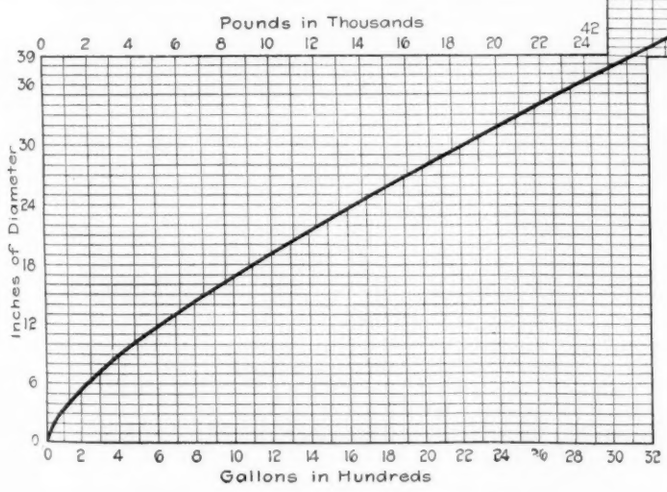
$$0.80 \times 43{,}430 = 34{,}744 \text{ lb.-ft.}$$

Volumes of Cylindrical Tanks*

By M. W. WARD

Cylindrical tanks set horizontally are so frequently used for the storage of liquids that a ready means is required for finding the quantity of liquid in a given tank at any depth.

ONE of the readiest methods of obtaining the volumes at different depths for a given tank would be from a curve that would read direct to either gallons or pounds for inches of depth; but a little consideration will show that by using the circular-segment formula, a large number of separate calculations must be made before such a curve can be plotted. Also, the determination of a set of constants, which could be used for any depth of any cylindrical tank, carries the investigator beyond the bounds of ordinary mathematics into the calculus, and the busy plant engineer seldom has the time or the inclination to pursue the matter thus far. In order that the desired result may be obtained with a minimum of trouble, the accompanying table has been prepared. This table gives the values of a volume constant V for each hundredth of the diameter of the tank. To find the volume of liquid in the tank at any depth, a stick graduated in hundredths of the diameter is put into the tank to determine the depth R of liquid. The value of V corresponding to this value of R is taken from the table and multiplied by the tank constant C and the product is the volume of liquid in gallons.



CONTENTS OF TANK 78 IN. IN DIAMETER AND 25 FT. LONG IN GALLONS AND POUNDS OF WATER

The tank constant is found, for a tank of a given diameter and length, by using the simple formula,

$$C = \frac{D^2}{100} \times L \div 231$$

in which C = tank constant; D = diameter of tank, in inches; L = length of tank, in inches.

The tank constant has a different value for every diameter or length of tank used, and so must be calculated for the particular size of tank to be considered. The contents of the tank in gallons G is then easily found by using the formula,

$$G = V \times C$$

To illustrate, suppose that a measuring stick graduated to hundredths of the diameter is put into a tank 6 ft. 6 in. in diameter and 25 ft. long and shows a depth reading of 20, and it is desired to know the volume of liquid in the tank.

According to the table the volume constant corresponding to a value of $R = 20$ is $V = 11.1824$. The diameter of the tank is 6 ft. 6 in., or 78 in., and the length is 25 ft., or 300 in. So the tank constant, according to the formula, is

$$C = \frac{78^2}{100} \times 300 \div 231 = 79.013$$

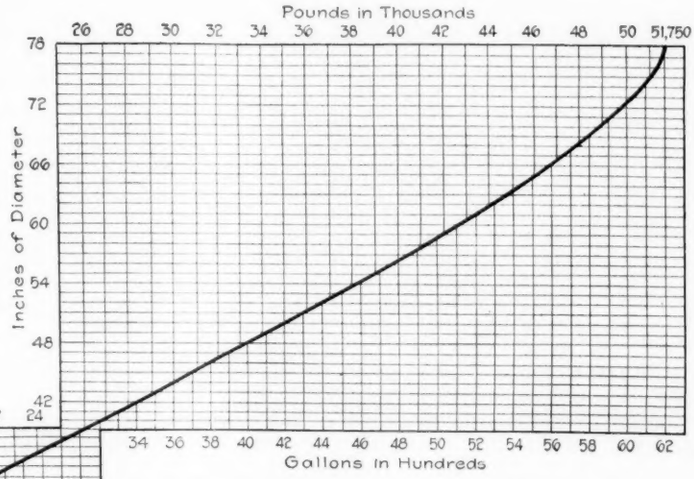
Therefore, the quantity of liquid in the tank at that depth is

$$G = 11.1824 \times 79.013 = 883.5 \text{ gal.}$$

For any other depth, in the same tank, the same value of C would be used, but a different value of V, corresponding to the depth reading.

From the preceding explanation it will be noticed that if all the values of the volume constants, as given in the table, were to be multiplied by the tank constant and the results tabulated, the result would be a table of gallons per hundredths of diameter. Such a table can be prepared for any particular tank either by long-hand multiplication of V and C or by aid of the slide rule.

Suppose that such a table has been prepared for the tank mentioned in the preceding example. The various values of the volumes in gallons in that table can then be used to construct a curve that will show directly the quantity of liquid at any depth. Such a curve is shown in the illustration, but the readings are given in both gallons and pounds, and are based on depths by inches instead of hundredths of the diameter. The weights are based on the assumption that the liquid is water. For any other liquid, of course, the scale of weights would be different. To use the curve, locate the depth reading



*See "Power," 1918, Jan. 22, p. 123; Apr. 2, p. 482.

along the left-hand edge of the diagram. Follow horizontally to the right until the intersection with the curve is reached. Then, if the volume in gallons is wanted, follow vertically downward from the intersection to the bottom of the diagram; but if the weight is wanted, follow vertically to the top of the diagram. The following explanation outlines the method to be used in the construction of such a curve:

First, by the use of the table and the tank-constant formula, calculate the volume of the tank, in gallons, for each hundredth of the diameter in depth, and arrange the results in a table of volumes.

Second, draw two lines at right angles to each other and on the horizontal lay off gallons to any convenient scale, say 200 gal. per in. On the vertical line mark off hundredths of diameter, to a scale of say one-hundredth to one-quarter inch. Then proceed to plot the points

VOLUME CONSTANTS AT DEPTHS VARYING BY HUNDREDTHS OF THE DIAMETER OF TANK

Depth Reading R	Volume Constant V	Depth Reading R	Volume Constant V	Depth Reading R	Volume Constant V	Depth Reading R	Volume Constant V
1	0.1329	26	16.2263	51	40.2698	76	64.0453
2	0.3749	27	17.1090	52	41.2694	77	64.8933
3	0.6866	28	18.0020	53	42.2681	78	65.7284
4	1.0538	29	18.9048	54	43.2656	79	66.5500
5	1.4681	30	19.8168	55	44.2615	80	67.3574
6	1.9239	31	20.7376	56	45.2555	81	68.1498
7	2.4168	32	21.6666	57	46.2470	82	68.9263
8	2.9435	33	22.6034	58	47.2356	83	69.6862
9	3.5012	34	23.5473	59	48.2211	84	70.4286
10	4.0875	35	24.4980	60	49.2028	85	71.1523
11	4.7006	36	25.4551	61	50.1805	86	71.8565
12	5.3385	37	26.4179	62	51.1537	87	72.5399
13	5.9999	38	27.3861	63	52.1219	88	73.2013
14	6.6883	39	28.3593	64	53.0847	89	73.8392
15	7.3875	40	29.3370	65	54.0418	90	74.4523
16	8.1112	41	30.3187	66	54.9925	91	75.0386
17	8.8536	42	31.3042	67	55.9364	92	75.5963
18	9.6135	43	32.2928	68	56.8732	93	76.1231
19	10.3900	44	33.2843	69	57.8022	94	76.6159
20	11.1824	45	34.2783	70	58.7230	95	77.0717
21	11.9898	46	35.2742	71	59.6350	96	77.4860
22	12.8114	47	36.2717	72	60.5378	97	77.8532
23	13.6465	48	37.2704	73	61.4308	98	78.1649
24	14.4945	49	38.2700	74	62.3135	99	78.4069
25	15.3546	50	39.2699	75	63.1852	100	78.5388

from the values given in the table of volumes previously calculated. When the points have been connected, the resulting curve should be smooth. Should this not be the case, errors have been made in computing some of the values in the table of volumes. These can be rectified and the curve made smooth.

Third, proceed to ink in the curve, together with the coördinates for gallons. Then erase the coördinates for hundredths of diameter and divide the vertical line representing the diameter of the tank into the same number of equal parts as there are inches in the diameter.

If an ordinary stick is used to find the depth of liquid in the tank, the wetted length can be measured with an ordinary foot rule, and the number of gallons or pounds at this depth can be read direct from the curve.

The values in pounds shown on the diagram are obtained by multiplying the total number of gallons that the tank contains when full by the weight per gallon of the liquid (8⅓ lb. for water) and dividing the horizontal line into any convenient number of divisions reading in either hundreds or thousands, as required.

The curve shown was plotted in two hours, the calculations being made by slide rule.

International Water Softener

There are few plants in operation that have not experienced one or more of the several disadvantages from using unsoftened boiler-feed water. The formation of hard scale on the water surfaces, its effect on boiler efficiency, capacity and upkeep, and the difficulty of removing it are matters of common knowledge, as is corrosion from acids formed by the breaking up of certain constituents at the higher temperatures within the boiler. Experience with the sources of trouble enumerated has emphasized the importance of eliminating the scale-forming material, precipitating it in the form of sludge and removing that portion of it which does not

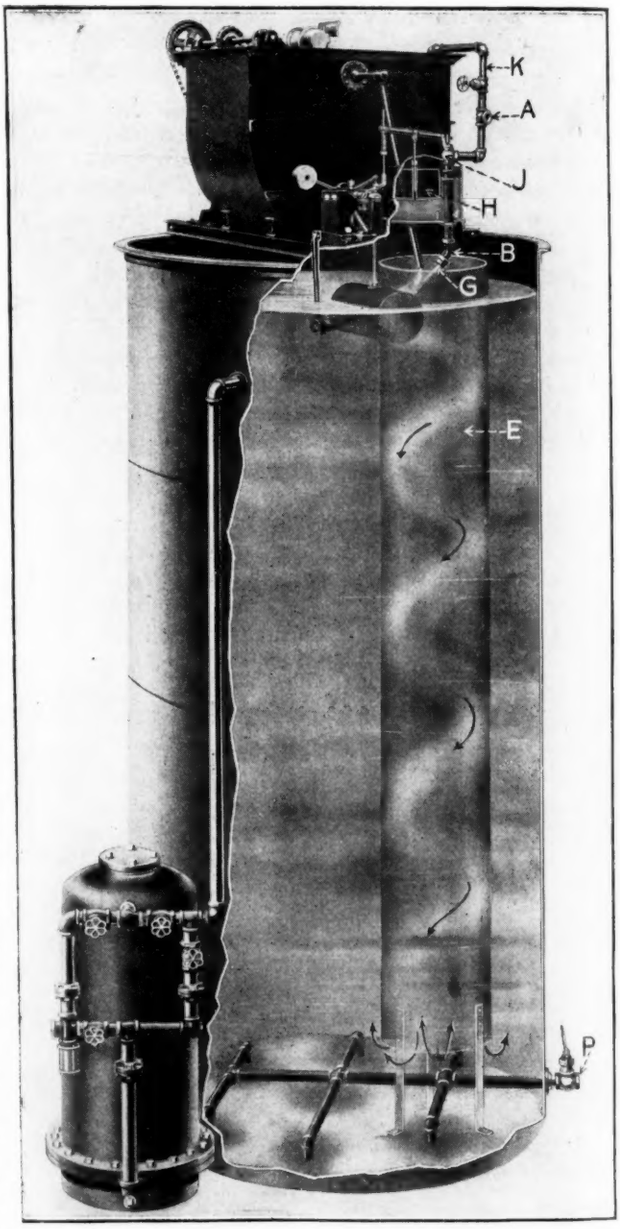


FIG. 1. INTERNATIONAL WATER SOFTENER AND DETACHED SAND FILTER

settle out in the softener by an efficient form of filter before the water is passed to the boiler.

In softening water a wide variety of chemicals, depending somewhat on the character of the water, may be used to precipitate the scale-forming matter. Hydrated lime and soda ash, however, are the reagents commonly used, as they are the least expensive and do the work effectively with no objectionable results. The question then resolves itself into selecting the apparatus that will thoroughly mix the chemical and incoming water with a minimum of oversight and choosing a

filter that will effectively remove the precipitated matter.

Softeners of the character mentioned, that are automatic in their action and are made in a variety of sizes and of varied construction to meet specific requirements, are furnished by the International Filter Co., of Chicago. In all of them the principle of operation is the same, so the present description will be limited to the smaller or "junior" sizes, ranging in capacity from 250 to 3500 gal. per hour. Fig. 1 is a sectional view showing the automatic control and the interior of the main softening tank. As the water admission is under a float control, the softener starts and stops automatically, the control being so arranged that the rate of flow is the same regardless of the pressure in the supply line. The raw water and the chemical fed into it are measured so that the predetermined ratio between the two is maintained. Attention is required each day for replenishing the charge of lime and soda ash, blowing off the accumulated sludge from the tank bottom and for washing the filter. In the interim the softener takes care of itself.

Referring to Fig. 1, the operation of the softener is as follows: Hard water enters through pipe *A*, discharging into the reaction chamber through a deflecting elbow at *B* and the orifice *G*. Here it meets a stream of lime and soda-ash solution from the chemical feed pipe. The water, being discharged at an angle, mixes with the chemical solution and is forced against the wall of the reaction chamber in such a way as to maintain a whirling motion in its course downward. By this rotary motion the water and chemicals are mixed and coagulation takes place in the downtake, or reaction, chamber *E*. In this chamber the impurities that make the water hard and form scale in the boiler precipitate, separating from the water in solid form as sediment or sludge. The greater portion of the sludge formed settles in the bottom of the tank and is blown out through the pick-up pipes and the valve *P*, which is opened at regular intervals for the purpose. The softened water rises slowly in the main tank and flows off to the filter, which removes the last trace of suspended matter. As previously intimated, the rate of flow of the raw water is maintained constant by float *H* acting on the control valve *J*. The orifice *G* is of such size that under the fixed head maintained by the float it will discharge the quantity of water the softener is built to handle.

In the chemical feed tank placed on top of the softener, chemicals for 12 to 24 hours' operation are placed and the tank is then filled with water from pipe *K*. In the tank are plow-shaped agitators, Fig. 2, driven by a small motor through a worm-gear reduction. The shape of the tank is such that the agitators keep the solution circulating in an up-and-down motion, preventing stratification and maintaining the solution at uniform strength in all parts of the tank.

Each end agitator carries a chemical measuring cup, shown in detail in Fig. 3. In passing over the collector funnel, Fig. 2, the cups discharge the required quantity of chemical, any excess in the cup flowing back into the tank. As the cups are rigidly attached to the agitators and cannot swing, the amount of chemical fed is always the same regardless of the depth of the liquid in the chemical tank.

The entrance to each cup, a long slot in the side wall, is surrounded by a screen which bars out any particles large enough to clog the discharge orifice. To withstand the action of the chemicals, the cups, collector funnels and agitators are all made of cast iron.

Even after settling four to six hours in the large tanks of the softener, the water is usually somewhat cloudy and also contains a small amount of dissolved matter that is just on the point of precipitating. This material is removed by a mechanical sand filter, Figs. 1 and 4. On account of the large amount of surface presented to the water by the grains of sand, the filter causes the precipitation of the material that has not already settled out and prevents any after deposits from the purified water.

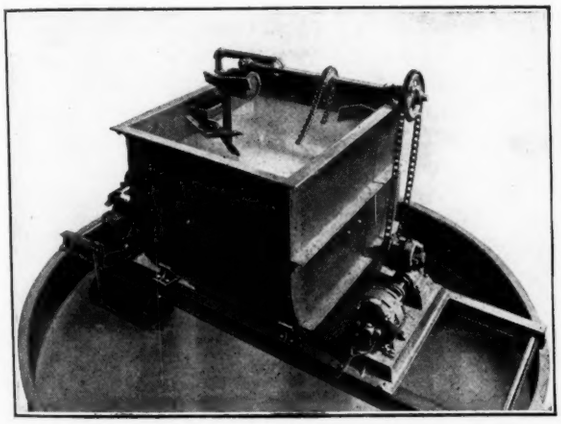


FIG. 2. CHEMICAL FEED TANK ON THE TOP OF SOFTENER

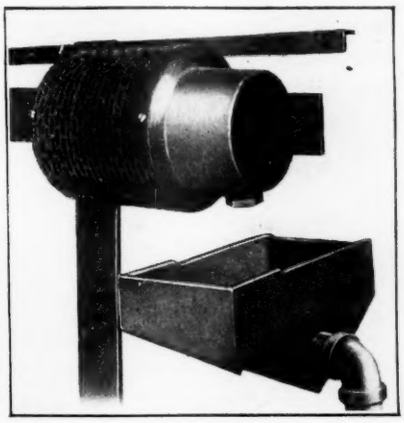


FIG. 3. CHEMICAL CUP AND COLLECTOR FUNNEL

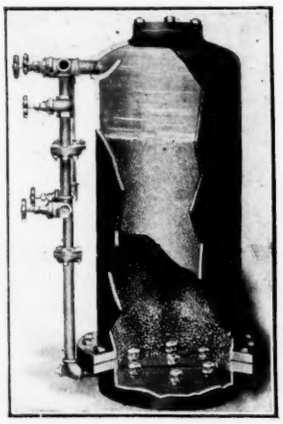
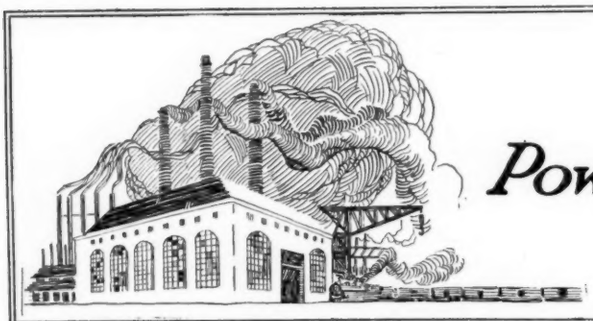


FIG. 4. SECTION THROUGH FILTER

The filter operates on the same principle as the large filter plants used through the country for purifying municipal water supply. The water filters downward through a bed of washed and graded sand resting on layers of graded gravel. The filtered water is collected in the sand valve system below the gravel and from there discharged through the outlet valve. The filter is detached from the main softener tank and may be placed at any point in the feed line. If desired, it can be located after the feed-water heater and thus collect the additional precipitation made possible by the higher temperature of the water.

To clean the filter the flow of water is reversed. Entering at the bottom, it passes up through the sand bed and carries the sediment out through the waste valve.



Modern Power Plant Education

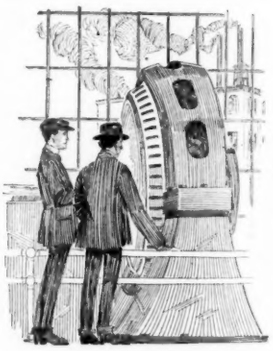
By C. A. Joerger

THE changes continually going on in power-plant engineering and the variety of ways a power-plant problem can be solved prompts a description of how the mechanical engineering department of the University of Cincinnati meets these conditions in teaching its students in power-plant work.

About twelve years ago Dean Herman Schneider started his "Coöperative" course for the engineering students. Today, overcoming all obstacles, it stands a distinct and decided success. The "Coöperative" course is one of five years' duration, eleven months in the year, six days in the week, leading to the degree of mechanical, electrical, civil, chemical or metallurgical engineer. A student desiring to enter the "Coöperative" course presents himself at the beginning of summer. If he has satisfied the entrance requirements, the head of the department in which he registers sends him to a shop where he is immediately employed. The nature of the work varies. He may be put in a foundry, a machine shop, boiler room, drafting room or any part of a plant that will help develop him as an engineer. In this way a student works about three months before the college year opens, and an idea of his ability and tastes is obtained, and he in turn learns what to expect to some extent, so that the dissatisfied and unsatisfactory ones are eliminated at the start and either leave or change their course.

At the beginning of the school year two "Coöperative" students become "alternates"; that is, one man works in a shop two weeks while his "alternate" is at school. The following two weeks they change about. In this way the firms always have a particular position filled. The men interested in power-plant engineering would work in one of the following departments: Foundry, machine shop, drafting, boiler room, rigging, engine testing, assembly floor, etc. From time to time men are, of course, changed from one department to another. Taking a particular case as an illustration, John Smith begins work July 1 in a foundry making castings for compressor, pump or engine parts. Oct. 1 he enters the College of Engineering in the department of mechanical engineering. He comes to school for two weeks and his alternate works in his place at the foundry. At the university Smith takes the prescribed subjects with the other engineering students. Every two weeks he changes places with his alternate. When the appropriate time comes he will be placed in the machine shop, where he will operate a lathe, then a planer, miller, grinder, etc. After a period in this work he is transferred to the drawing room. Finally he goes to the assembly and test floor, where responsibility is placed on him. Later he becomes an erector and test engineer. No two men go through identical courses. Another man may start as a fireman in the boiler room, then become foreman of the boiler room, later do rigging and construction work, go into the engine room; then perhaps go into a concern making refrigerating machinery. Everything depends on the man's ability, wishes and what the mechanical engineering department thinks he is best fitted for.

At the university a course called "Coördination" is given, in which the men meet and exchange shop ideas and views, straighten out troubles and discuss new features. It is a clearing-house course. Questions that tend to stimulate the men's powers of observation are asked by the instructor, and he points out features of their work which have a direct bearing on their studies. A student employed at a plant manufacturing centrifugal pumps explains their construction and performance under test; another student explains the manufacture and test of some form of duplex pumps, and soon a very interesting discussion as to the relative merits of each is going on and it is plain that students learn practical, everyday engineering. At the end of the course practically every phase of engineering work has been discussed. This interchange of ideas makes the student a more intelligent workman, and he becomes of greater value to his employer.



Beginning with the third year the student specializes in his work at the university and at the shop. The power-plant student takes a course called "Steam Engineering." He still takes the regular prescribed academic courses, but more and more he specializes in courses that fit him for his future work. In "steam" he has daily assignments in Gebhardt's "Steam Power Plant Engineering." Once a week an afternoon is spent visiting a shop where the work of the week is

shown in actual practice. Thus, when studying boilers, a boiler shop is visited; when studying engines, an engine shop is visited; when studying stokers, a plant installing stokers is visited; when designing a power plant, a plant under construction is visited, and so on throughout the year. At the shops questions are asked that show the points studied during the week. In this way students get in touch with real engineering, and they consequently take their work more seriously.

A written report is made of each shop visited. These reports go to the department of English first, then to the instructor in mechanical engineering who arranged the trips. He corrects them for accuracy of content. The mechanical engineering laboratory is just as intensely practical. The men not only work out all the usual experiments incidental to a mechanical laboratory, but in addition they do actual test work. A firm desirous of having an engine, boiler, machine or plant tested informs the university, and a group of students in charge of a capable instructor perform the required test according to the very latest codes and methods. Each student turns in a complete record and report; the firm is then given a record and report. This method develops the qualities of responsibility and initiative in a man.

Once a week the technical journals are gone over and new plant installations and new problems discussed. The real purpose of this is to cultivate the habit of reading magazines, although naturally much useful information is acquired.

As the student develops, the more difficult subjects are taken up, including gas engineering, production engineering, thermodynamics, etc. In all cases he is instructed in the application of the subject, and wherever possible he is taken to a plant and shown the application. At the same time a student is probably working at a plant in which the principles he is studying are either directly or indirectly involved. Thus a course in thermodynamics, which is usually a bore to most men, becomes interesting to a man working in an engine shop, compressor shop, or refrigerating-machinery shop. This modern scheme of engineering education has advantages to all concerned. The student has a chance to earn his way through college; he develops initiative, self-reliance and industry, and he gets that all-important thing—contact with machines and men before he graduates, thus getting a good start to become a true and real engineer or manager.

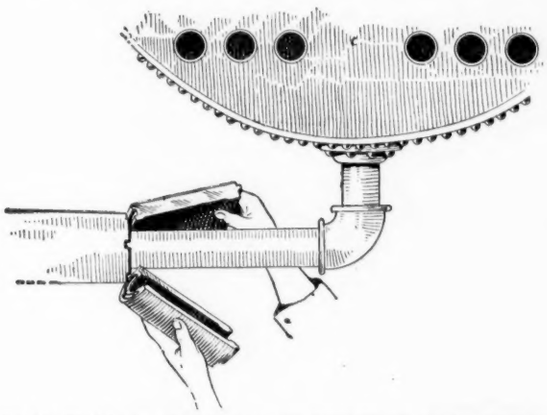
The university gains by the fact that no shops are necessary, and the classrooms, drawing rooms and laboratory facilities are doubled. The university, of course, builds up a reputation by means of its accomplishments. The shops gain by the fact that the arrangement is a profitable one for them. A "Coöperative" student excels the ordinary workman, and at the time of his graduation he is a trained man ready to step into the organization as an efficient employee.

E-Z-Set Sectional Blowoff Pipe Sleeves

If there is one thing above another that requires protection against the intense heat of the furnace gases, it is the boiler blowoff pipe, and especially so if the boiler-feed water contains scale-forming salts.

Engineers who have realized this have supplied home-made protection such as building brick baffle walls in front of the blowoff pipe, applying asbestos to the pipe, etc. In many instances, however, the blowoff pipe has been left to take care of itself.

The ideal blowoff-pipe covering would be something in the sectional design that could be easily removed for an inspection of the pipe and as easily replaced. Such a covering is made by Orosco C. Woolson, 39 Cortlandt St., New York City. It is of special



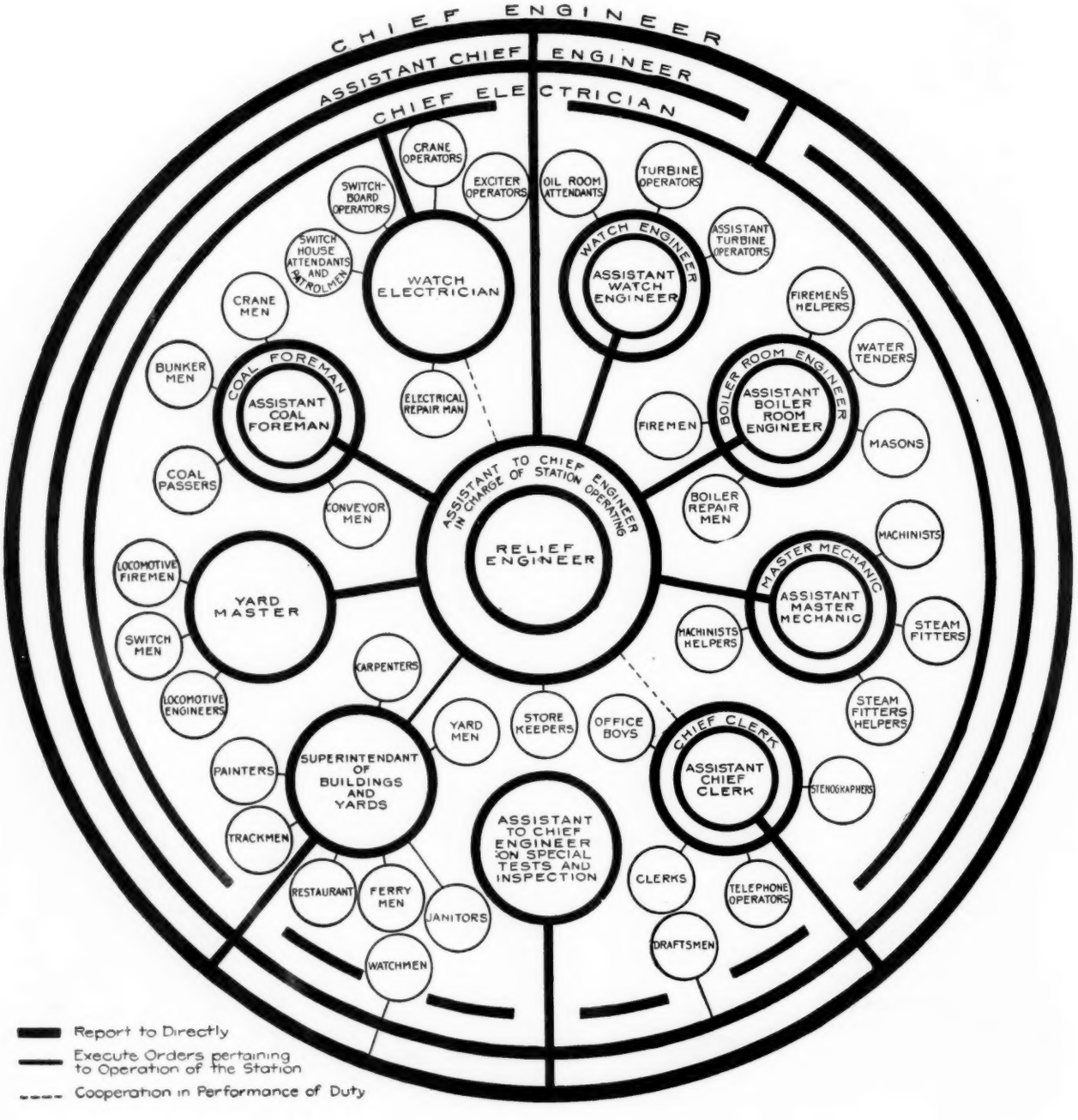
APPLICATION OF SECTIONAL SLEEVES TO BLOWOFF PIP

fireclay, capable of resisting a high temperature and is made in 4-, 5- and 10-in. lengths. The ends of the split sections are provided with suitable grooves and tongues so arranged that the split of one section cannot line up with that of another. The sleeves are held in position when applied to vertical pipe by a split iron collar which is attached to the pipe. At the top a crown collar protects the rivets of the flange on the boiler. The illustration shows the application of the sleeve. Split coverings are also made for ells and bent pipe sections. All joints are made tight with thin asbestos cement.

Regardless of whether, under the Ohio statutes, a power company's adoption of a plan for water-power development vested in it a preferential right, as against rival power companies or municipalities, to appropriate the property embraced in such plan, the Ohio constitution reserves to the state to revoke any such right to appropriate property until the privilege has been exercised through the power company's acquisition of such property. The riparian rights of a power company consisting of a small parcel of land extending to high-water mark below a dam and reservoir constructed by a city for water-supply purposes, a contract with an owner below the dam for a portion of the river bed with a right to regulate flowage, and options on other lands and rights, all of which were apparently acquired after the city's water development was practically completed, did not entitle such company to enjoin further construction of the dam and reservoir and the diversion of water by the city. (U. S. Supreme Court, Sears vs. City of Akron, 38 Supreme Court Reporter, 245.)

Power-Station Organization Chart

The yearly kilowatt-hour output of the Commonwealth Edison Co. is the largest of any central-station company in the United States and certainly in the world, being 1,448,080,000 kw.-hr. in 1917. The form of the chart is unique. There are virtually ten bureau heads, including the chief electrician, responsible to the chief engineer. The coal foreman, watch engineer, boiler-room engineer, master mechanic and yard master report to the assistant to the chief of operating. The superintendent of buildings, research engineer and chief clerk report to the chief or assistant chief engineer. The watch electricians report directly to the chief electrician. Notice that the watchmen and draftsmen report directly to the chief and assistant chief engineers.



Economizer Explodes at New Orleans Railway and Light Company's Plant

An explosion of the No. 3 economizer at the Central Power Plant of the New Orleans (La.) Railway and Light Co., occurred at 6 p.m., June 10. Two boiler-room attendants were fatally injured and a number of others received minor hurts. It may be considered fortunate that the accident was concerned with an economizer on the side of the boiler house away from the engine room.

The boiler house is of the double-deck type, the lower deck being on a level with the engine-room floor. The boilers are set with their backs to the sides of the room, with the firing floor between the boiler fronts, as is the usual custom. The No. 3 economizer was located on the lower deck at *A*, Fig. 1, which is an outline plan of the engine and boiler rooms. Had the economizer on the opposite side of the boiler room exploded, the damage to the generating equipment would no doubt have been very severe and would probably have resulted in a prolonged shutdown of the plant.

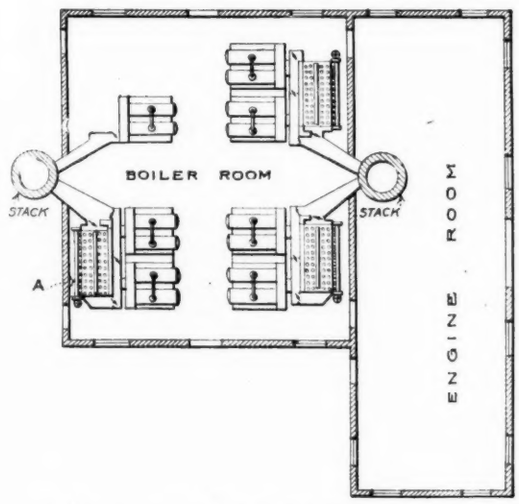


FIG. 1. OUTLINE PLAN OF THE ENGINE AND BOILER ROOMS

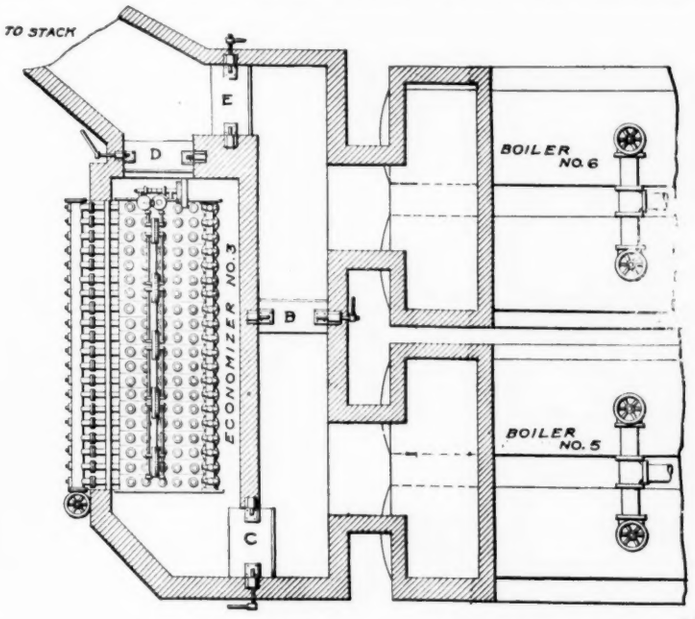


FIG. 2. ARRANGEMENT OF DAMPERS AND FLUE CONNECTIONS

There are six economizers used in this plant, two of these being high-pressure units located between the feed pumps and the boilers, and the other four are operated at a pressure of about 90 lb. The exploded economizer was one of those operated at the lower pressure. Three-stage, electrically driven pumps were used in connection with the low-pressure economizers. The first stage pumped the water into the economizer at a pressure of about 90 lb. The other two stages were connected between the economizer and the boilers, and boosted the pressure up to a point that permitted the water to flow into the boilers, which are operated at 185 lb. The equipment was first-class in every respect. The capacity of the electrically driven centrifugal pumps was not what it should have been, and new steam-driven pumps were on the ground to replace them, but lack of pump capacity had no connection with this accident. The economizer that exploded was not in service at the time of the explosion.

The gas connections to the exploded economizer were as shown in Fig. 2. Damper *B*, located in the direct flue to the stack and between boilers 5 and 6, was usually operated closed or partly closed. There was insufficient flue area through the economizer to allow the gases from both boilers to pass through and maintain proper draft for forced conditions of operation. At the time of the accident No. 6 boiler was idle and No. 3 economizer out of use. Dampers *B* and *E* were reported to be wide open, with *C* and *D* closed. Boiler No. 5 was on the line and delivering a heavy overload.

Under such conditions the direct flue connection was probably taxed to its limit. The most plausible theory to account for the fact that conditions were reached in the economizer that caused an explosion, are as follows: Either dampers *C* and *D* were not closed tightly, or they had been opened to aid in furnishing sufficient draft to No. 5 boiler so that it might carry the overload under which it was operating. Under such conditions the economizer, being shut off as far as water connections were concerned, would no doubt become heated to a point where an explosion would occur in a relatively short period of time. The explosion wrecked the dampers to such an extent that there was no way of telling in what position they may have been just prior to the accident.

The vent connection to the exploded economizer —all the economizers in the plant being supplied with such connections—was reported to have been open at the time of the accident. If this was the case, the connection was either plugged with sediment so as to prevent the escape of the contents entirely, or to afford so little relief that a steaming condition under considerable pressure could be reached. The lack of evidence of extreme violence, as generally noted in economizer explosions, seemed to indicate that this explosion occured at a moderate pressure, probably not over one hundred pounds. The property damage at the time of the accident was estimated to be in the neighborhood of $50,000.

Future Electric-Power Supply for the United Kingdom

The committee appointed some time ago by the Board of Trade to consider the question of electric-power supply in the future has issued its report. The proposals made by the committee may be outlined as follows:

1. That a new body, to be called the Electricity Commissioners, should be set up, to whom should be transferred the existing powers of the Board of Trade, Local Government Board, Local Government Board for Ireland, and Scottish Office, relating to the supply of electricity, and to whom large additional powers should be given for regulating and encouraging the generation and distribution of electricity.

2. That the Electricity Commissioners should, subject to an appeal to Parliament in certain cases, have general control over the generation and distribution of electricity in the United Kingdom.

3. That the existing system, under which electricity is separately generated for small areas, should be abolished.

4. That the Electricity Commissioners should, after local inquiries, divide the United Kingdom into districts technically suitable for the economical generation and distribution of electricity.

5. That in each electrical district a District Electricity Board should be set up, which should purchase all generating stations of authorized distributors, whether local authorities, companies, or power companies.

6. That the District Electricity Board should be responsible, by themselves or their lessees, for the future generation of electricity in their district, and for the establishment of new generating stations and proper systems for the main transmission of electricity in their district.

7. That existing electrical undertakers should, if they so desire, retain their power of distributing electricity within their local areas, but should purchase electricity in bulk from the District Electricity Boards or their lessees, due provisions being made for controlling the profits of distributors so as to insure a cheap supply of electricity to consumers.

8. That District Electricity Boards should make no divisible profits.

9. That District Electricity Boards should be financed, in whole or in part, by funds raised with government assistance, except where it is shown to be desirable and practicable to finance the boards locally.

10. That largely extended powers should be granted for, *inter alia:* (1) The use of overhead wires. (2) Wayleaves. (3) Acquisition of water rights.

Do You Watch the Sewer?

By Victor J. Azbe

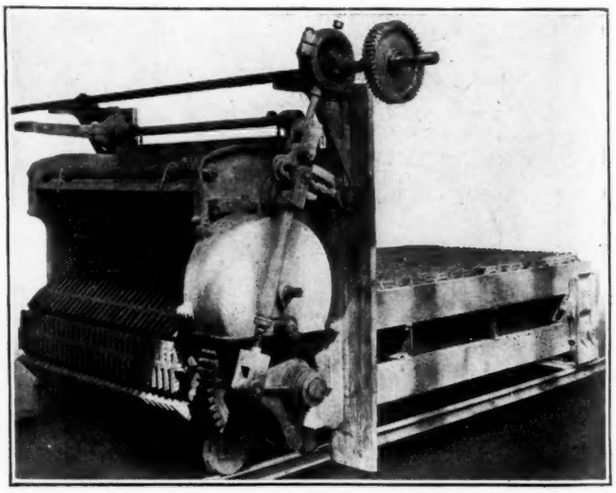
A certain successful engineer's first act upon taking charge of a plant was to have the sewer exposed so that at all times he was able to see what was going through. This appears to be an extreme move; it is common sense. The loss to many plants from unknown leaks, unknown open valves, leaking traps, blowoffs, drains, valves, overflows, etc., is indeed great.

To determine actually what a plant is using is simple; to determine what a plant ought to use is not so simple. Engineers should always work in the direction in which they will have a balance of the heat input and work output. In this balance the unknown quantity will be a variable percentage, but always a large one. It is the sewer, ordinarily, that makes this quantity so large. Carefully made out balances on performances of certain plants showed a loss of 20 per cent. of the total power and steam.

In many plants too many so-called negligible leaks are allowed to continue. By neglecting small leaks one gets into the habit of overlooking larger ones.

Brady Traveling-Grate Stoker

A new mechanical stoker, illustrated herewith, has been developed recently by Joseph Harrington, advisory engineer of the James A. Brady Foundry Co., of Chicago. The general design is of the traveling-grate type, the grate surface being formed of a large number



BRADY TRAVELING-GRATE STOKER

of small bars supported on transverse racks or beams in such a manner that the various sections interlock and present a continuous grate surface.

The transverse racks supporting the grate bars rest on three spans of semi-steel chains, each link of which has a chilled iron roller, so that the entire grate moves on roller bearings removed from the heat of the fire. The members of the grate in near proximity to the fire are not subjected to tension and are free to expand. The grate bars do not rise above the level of the grate surface at the rear turn and are thus protected from burning.

The stoker is operated through a heavy but simple adjusting lever to a train of cast-iron gears inclosed in a housing to prevent coal from getting into the gear teeth. The speed can be varied from maximum to minimum or from one tooth on the ratchet wheel to five by shifting the position of the connecting-rod from one recess to another. The frame of the stoker consists of steel channels located below the effect of the fire and, on account of the truss effect of the channels, is exceedingly rigid. The usual features of adjustable ventilated gate, removable hopper front, slotted wheels for

withdrawing from the furnace and interior baffles have been incorporated.

Provision has been made so that the stoker can be divided into sections and each section provided with dampers to regulate the supply of air to the various parts of the fire as desired. The stoker is also adapted for forced blast, and high rates of combustion can be obtained.

Ray Fuel-Oil Burner

The W. S. Ray Manufacturing Co., of San Francisco, Calif., has devised a method of atomizing oil in an open cup lying horizontally and driven at 3450 r.p.m., and then forcing the air at high velocity around the cup and in a direction away from it. By this method there is not only introduced sufficient air for proper combustion, but also enough to direct the flame into the furnace. Naturally, the air leaving the blower will be turning in the same direction as the atomizer, causing the fire to be unsteady and having a tendency to throw oil on all sides of furnace; but this is overcome by inserting guide vanes in a nozzle surrounding the atomizer, which directs the air from a revolving motion to a straight path.

The Ray burner is standardized with a Westinghouse inclosed motor *A*, Fig. 1. The hollow shaft *B* of this motor is extended to permit a worm reduction gear to be fastened to the center of the shaft, and a blower *D* and atomizer *E* are attached to the end opposite the motor. A ball bearing is used at each side of the worm gear, which is incased in a housing *C* that is constructed with an oil well at the base. This gives the two bearings a splash feed, which is positive, and removes the danger of either under-oiling or over-oiling.

The motor jacket is cast with a hollow frame so as to incase the motor and allow the fuel oil to pass around it. This lengthens the life of the motor by keeping it cool and at the same time warms the oil somewhat before it is introduced for combustion. It also permits the use of the burner in a boiler room with a temperature so high that an ordinary open motor would overheat and burn out.

In operation the fuel oil passes through the strainer *G* and is controlled by the valve *H*. After passing through this valve, the oil goes through the connection shown at the end of the motor, through the stationary oil-supply tube *J*, from which it discharges into the atomizer *E*. Air from the blower passes between the guide vanes *K* and the atomizer *E*, as shown in the illustration.

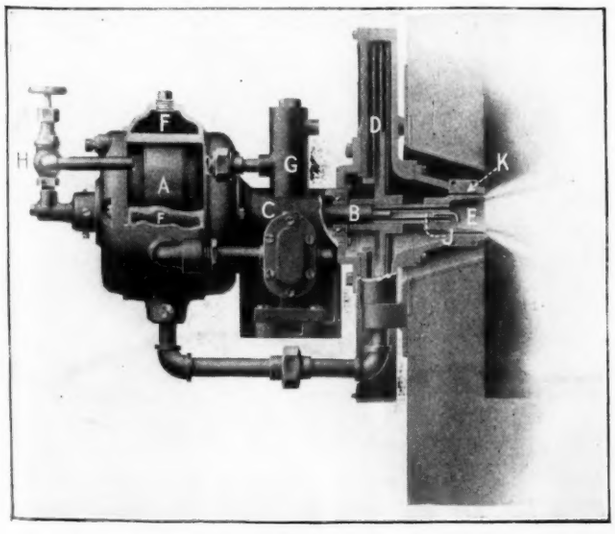


FIG. 1. DETAILS OF THE RAY FUEL-OIL BURNER

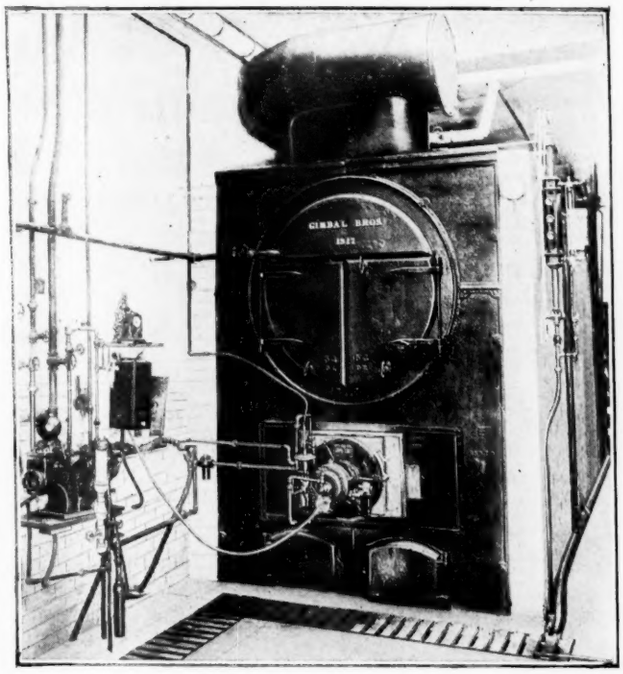


FIG. 2. FUEL-OIL BURNER APPLIED TO A BOILER FRONT

Except in domestic stoves, fuel oil as low as 14 gravity can be burned successfully without smoke, soot or dirt in all types of furnaces where high heat is necessary. The burner is flexible in its application and can be used in anything from a hot-air furnace in a private residence to a 500-hp. boiler installation. Fig. 2 shows the application of this burner to a horizontal-tubular boiler.

The Springfield, Mo., Court of Appeals has affirmed judgment for $7500 in favor of plaintiff in the case of Anderson vs. Lusk, 202 Southwestern Reporter, 304, on account of injuries sustained by him while engaged in assisting in putting plugs or "sunflowers" in the front flue sheet of a boiler, in the process of eliminating flues.

At the time of the accident plaintiff was inserting one of the plugs and, under directions of a foreman, was using a pry on a wrench to tighten the plug. The foreman, deeming another turn necessary, directed plaintiff to apply the pry again. This caused the threads in the flue hole to strip suddenly, resulting in plaintiff sustaining serious injury. In supporting verdict in his favor, the court decided that the foreman's declaration immediately after the accident, that he was "afraid of that," was competent evidence that he had negligently exposed plaintiff to injury. The opinion further shows that liability was properly based on any negligence in failing to have the threads cut deep enough to hold the plug; and that plaintiff cannot be regarded as having assumed the risk of being injured in the manner in which he was injured unless the peril was so obvious that a workman of ordinary prudence would not have encountered it.

Another Fuel Administrator Plays the Central Station's Game

POWER has several times called attention to the activities of members of the Fuel Administration in the interest of the central station. The apparent influence of the public-service corporations in a governmental department so full of potency for popular good, if properly administered, is to be deplored. What are *you* going to do about it?

The following letters tell their own story:

United States Fuel Administration.
Boston, Mass.,
July 8, 1918.

Taunton City Council,
City Hall, Taunton, Mass.

Gentlemen:

The following is to confirm a statement that I made, as a representative of the Massachusetts Fuel Administration, at a meeting of the Taunton City Council held July 6, 1918, in regard to saving coal at the municipal lighting plant.

Investigation of the municipal power plant shows that it will be impossible to increase the efficiency of the plant within a reasonable length of time to such an extent that it will compare favorably in coal consumption per unit of power generated with that of an efficient plant.

As there are efficient plants within a reasonable distance of Taunton, you would make a greater saving by purchasing power from one of these than by improving and enlarging the Taunton plant. Therefore, in view of the necessity of conserving the maximum amount of coal possible, we strongly urge you to purchase power. Very truly yours,

HOLBROOK LINCOLN.

To His Honor, the Mayor, and Members of the City Council.

On the 8th of July, 1918, in company with Mayor J. William Flood, mayor of the City of Taunton, I personally visited the Fuel Administrator of the Commonwealth of Massachusetts, Mr. James J. Storrow, at his office, State House, Boston.

At our request, Mr. Lincoln, who addressed your board last Saturday, was summoned to the interview. We told Mr. Storrow that Mr. Lincoln, assuming to represent the Fuel Administrator in this commonwealth, made the statement to your board on Saturday last that in the event that the City of Taunton, through its municipal council, declined to purchase power or current of some surrounding plants, who were ready and willing to furnish it to the City of Taunton, that in that event the Fuel Administrator might refuse to furnish the City of Taunton with the necessary amount of coal to properly run and maintain its plant during the coming winter.

We also told Mr. Storrow that, in answer to a question propounded by one of the council, Mr. Lincoln made the statement that there was no alternative left open to the City of Taunton except that of purchasing power, for the reason that, where the city declined to avail itself of power from some outside generating plant, the Fuel Administration would not readily assist the city.

Mr. Storrow, in the presence of Mr. Lincoln and in the presence of the mayor and myself, reprimanded Mr. Lincoln for his statement thus made, and in our presence told him he was without authorization for that statement.

Mr. Storrow told us he did not want to see our plant junked. That he was interested solely in the conservation of coal. He also suggested to us that if the Narragansett or any other generating plant refused to make a contract with the City of Taunton to run only during the war, with its necessitated coal shortage, then the City of Taunton ought not to do business with it or any other such plant.

I present this statement to this board in order that any misunderstanding or misapprehension of the real facts caused by any statement of Mr. Lincoln might now be corrected. I deem it my duty to lay the truth before you and the taxpayers of this city, in order that the true situation may be known and appreciated.

I respectfully request that this statement be spread upon the records of your council.

Respectfully submitted,
DAVID BERTHIAUME,
Manager Taunton Municipal
Lighting Plant.

From the Freemont, Neb., Tribune: "Grand Island, Neb., July 6.—The city council and the officers of the Central Power Co., who are confronted with the request of the national fuel administration to conserve coal by merging the electric manufacturing plants, have temporarily become involved in a deadlock, the outcome of which is yet doubtful.

"After several conferences between the engineers and managers of both plants it was unanimously agreed that no coal would be saved simply by a merging of the steam plants, and that conservation, as desired by the national fuel administration could only be attained by the combined use of the Central Power Co.'s hydro station at Boelus.

"It develops, however, that since its construction the water power plant has been out of commission by the undermining of quicksand upon three separate occasions and has only within ten days been connected up for the first time in five or six months. City authorities are inclined to regard reliance upon the water as very doubtful, and the Central Power Co. is reported to have been opposed to the city's purchase of current from the power company, the distribution to be made by the city.

"It is believed that the national administration is under the impression that a large amount of the electricity here is furnished by water power, which on account of washouts and undermining at the plant, is said not to have been the case."

Certainly the Fuel Administration does not wish to make the citizens abandon the municipal plant for a water-power station that falls into the creek every three weeks. Here evidently, is an opportunity for the Administration to do real service by giving every assistance and exacting every reasonable act necessary to make the water-power power plant give maximum output.

EDITORIALS

Value of Reports in Relations of Engineer and Owner

IT IS a common cause of complaint among operating engineers, especially in small plants, that their services and their relative importance to the other departments of the establishment are underestimated, and this very often is the case. The reason for this state of affairs is that the engineer, in the great majority of cases, does not come into frequent contact with the heads of the concern, and as a result they do not realize the many problems and conditions with which he has to contend. Usually the engineer keeps the plant going, and the owners pay the bills without much question. One is usually discontented because his efforts are not more fully appreciated, and the other is usually suspicious that his power is costing him more than it should; but nothing worth while is accomplished between them because they do not "get together."

One of the most effective weapons in the hands of the operating man for securing a better coöperation—and one which is rarely used—is the annual or semiannual report covering what has been accomplished during the year or half-year, what the power load and costs have been, what handicaps have been overcome, what equipment is doing good work, what equipment is uneconomical and should be replaced, and containing other recommendations or suggestions for improvements.

Such a résumé, made properly and completely, involves extra work on the part of the engineer, but it should be directly beneficial to him in many ways. The making up of such a report once or twice a year necessitates a study of the conditions of operation in the plant and directs attention to many phases of the work that ordinarily are overlooked in the course of routine operation. In other words, it gives him a better grasp of the situation.

A statement of the handicaps, the accidents, the breakdowns that have occurred during the period will also bring to the attention of the men higher up the value of the engineer in overcoming difficulties and often will result in the removal of the causes. A statement in condensed form of the load carried and the power costs makes this information available for comparison with previous records, and gives the owner a basis on which to judge the work of the men and the value of proper supervision.

Then the engineer's recommendations as to what old equipment should be replaced or what new equipment should be added to the plant, presented with the proper reasons for making the change and the probable rate of return on the investment, are given to the management in such form that they can scarcely be overlooked and, coming at a time when the owner's attention is concentrated on the power plant and its work, are more likely to be acted upon or considered.

Even though the suggestions are not then acted upon, they form a permanent record of the engineer's recommendations, and when the matter is brought up for action at a later date, the discovery of the previous recommendation will go far to convince the owners of his foresight and insight into the needs and requirements of the plant.

The effect on the management of the interest and capability of the engineer, as represented by a careful statement of conditions and opportunities for improvement, will serve to impress upon them the fact that the engineer is strictly "on the job," and it is not stretching a point to say that the submission of a first-class annual report by the engineer is one of the quickest and surest means of securing him an increase in salary.

The head of the modern business concern is accustomed to secure from his various department heads regular reports as to what has been accomplished, what changes can be made to advantage, etc., and the engineer immediately puts himself in the same category as these department heads—and incidentally obtains the same measure of consideration and appreciation—when he begins to lay before the management in neat, compact, interesting form information and data as to what he is accomplishing and what equipment he needs for still better results. With these reports, the engineer brings himself into direct contact with the owner, shows him what he is doing and brings himself out of the obscurity of the power house.

There is no phase of modern business on which more interesting reports or more comprehensive recommendations can be made than the power plant, and if the engineer keeps a daily log of the plant performance and keeps his eyes open for desirable improvements, he should be able to present a yearly or half-yearly condensed statement that will secure for him the respect and confidence of his employer, which is often followed by increased compensation and more agreeable relations. The making of an annual report represents a means of betterment that should be employed by every engineer who knows what his plant has done, who knows its needs, and who can state these facts in plain convincing language.

Nothing Else to the Game

THE representatives of the central-station industry derive deep satisfaction from pointing out that the small isolated plant is on the wane and that it will shortly be relegated to the cobwebby corner, along with hoopskirts, bustles, side whiskers and other impedimenta of a bygone age.

Fortunately—or unfortunately, as you may choose to view it—the spokesmen for the central station occasionally tell something more than half-truths when they speak of their plants. Not long ago one of these friends of central-station monopoly expressed himself as follows:

> To those of us who may in the future come in contact with the design or operation of such stations, practically

one simple rule only is necessary to bring about the best economy—burn your fuel in the most efficient manner possible to convert the greatest portion of the heat units in it into steam, and then utilize that steam quickly, practically and thoroughly so that just as few as possible of those heat units get out and escape to be forever lost to mankind. There is really nothing else to the game. We can say that we are generating and distributing electrical energy, or we may call it by any fancy name we choose, but the fact of the matter is we are selling heat units. It is heat we are selling through electrical service just as much as if we were actually peddling coal to our customers.

Simple, isn't it? Nothing else to it but to keep heat units from escaping and being forever lost to mankind!

That being the case, what about the thousand-odd British thermal units rejected into the condenser with every pound of steam in central station practice? Doesn't that represent a waste of something like eighty per cent. of the original heat content of the steam? And isn't it forever lost to mankind?

Of course, the central station has a counter-argument. Look at the marvelous economy of less than two pounds of coal per kilowatt-hour, whereas the isolated plant takes five or ten!

That's all very well, as far as it goes. But the point at issue is the permanent loss of heat units. Why let that eighty per cent. of the heat go to waste?

Again a plausible explanation is forthcoming. The central station must have a high vacuum in order to show high efficiency, and a vacuum naturally involves condensation of the steam. It is one of the necessary conditions of operation.

True enough. But that explanation does not explain—it merely excuses. On the same basis, the noncondensing plant might plead extenuating circumstances as an excuse for discharging exhaust steam into the atmosphere.

There is no denying that the larger central electric-power stations do obtain splendid results in the way of efficiency when compared with other plants using steam for the production of electric power only. Even at that, they seldom are able to convert more than twenty per cent. of the available heat energy in the steam into useful work. Judged on the basis of letting as few heat units as possible escape unutilized, the central station is more than eighty per cent. wasteful. Yet its friends would be highly indignant if it were accused of waste without a qualifying statement as to the conditions under which it must operate.

The isolated plant, however, should be accorded equal consideration. It is manifestly unfair to speak of all small plants as being uneconomical, without qualification of some sort. If the steam is first used to develop power and then to perform heating, drying, washing and various manufacturing processes, the over-all steam efficiency may run very close to one hundred per cent., which is a record that the average central electric station cannot begin to approach.

There is a general failure to appreciate the fact that the discharge of exhaust steam into a condenser is just as much a waste of heat energy—and therefore of fuel—as its discharge into the atmosphere from a noncondensing engine or pump. In one case the circulating water carries off the heat and in the other the air performs the same function; but in both the heat gets away and is forever lost to mankind—at least in available form.

Both the central station and the isolated plant are needed, but not under like conditions of operation. Neither one can efficiently fill the field of the other—and should not attempt to do so. On the other hand, there should be intelligent coöperation between the two, to the end that the maximum of useful effect—whether it be electric power, light, or heat—may be obtained with the least expenditure of that vital necessity, coal.

For the greater part of the year the small isolated plant performs more useful service per pound of coal than the large condensing plant. During the remainder of the year it is exceedingly wasteful of fuel and might profitably be shut down during that period in favor of the central station.

All the talk and turmoil about fuel conservation boils down to the simple matter of letting just as few heat units as possible escape without doing some useful work, and both the central station and the isolated plant would do well to memorize that brief text. There is really nothing else to the game.

Fuel Oil After the War

THE poilu in times of distress cheers himself by affirming that some day the war will be over. And it will, of course with the poilu and his comrades victorious. So it is likely to be with fuel oil, particularly along the Gulf and Atlantic coasts. Just prior to the war New England was considering with increasing favor the adoption of fuel oil for steam boilers. Until recently fuel oil displaced coal for 85,000 horsepower in that section.

Then came the shortage of ships, our participation in the war as a belligerent and the consequent unprecedented demand for fuel oil by the Government. Many who were about to use oil abandoned the thought; the oil was not available, and the oil companies would make no contracts nor promises of delivery.

But some day the war will be over, the Mexican situation doubtless will be peaceful and favorable, marine and rail transportation will be adequate and regular and oil available at a price worth considering. Fuel oil, in the East at least, may be forgotten as steam fuel until Potsdam and Great Headquarters throw up their hands and cry "kamerad!" which will be just as short a time as the Allied armies can make it.

The production of bituminous coal during the week of July 13 was the largest on record. The Government ordered 101,090 freight cars in May. Organization, method, unbounded means, the hearty coöperation of labor and a universal appreciation of the fact that a ton of coal saved is better than another ton mined will prevent any recurrence of the conditions of last winter. But remember he who wastes is a public enemy and he who does not put forth his best efforts to economize is a slacker.

The lightless nights are here again. However much the hot weather may make one scorn coal, the Fuel Administration is right in reminding the nation that we must conserve to meet the fuel shortage.

Over one hundred thousand freight cars ordered in May. This ought to help relieve the car shortage.

CORRESPONDENCE

Supporting Effect of Boiler Heads

I read with interest Mr. Macdonald's article in the May 21 issue of *Power*. I do not agree with the conclusions he has reached, and in regard to the bracing of cylindrical furnaces in upright boilers there is a conflict between Mr. Macdonald's reasoning and the method of design set forth in the A. S. M. E. Boiler Code.

In the illustration of the two stone walls, no credit is given to the weaker wall for the strength it does possess, and the fact is lost sight of that until a pressure of 296 lb. is reached, no tension whatever is put upon the cable. In fact, no cable is necessary up to this point. Everything in excess of 296 lb., however, must be carried by the cable, and the total strength of the structure is that of the weaker wall plus that of the cable.

In the case of boiler surfaces an accurate analysis would require account to be taken of the elasticity of the materials in question. The initial strains put in braces and stays in assembling and riveting up make it impossible to foretell with any accuracy when the stays will begin to take some of the load imposed upon the surfaces which they support. In view of these facts no account is taken of the strength of flat plates when staying flat surfaces, as, for example, the tube sheets of shell boilers and the crown-sheets and sides of the fireboxes in locomotive-type boilers. However, the A. S. M. E. Boiler Code states that the cylindrical fireboxes of vertical boilers must be stayed as flat surfaces only when said fireboxes exceed 38 in. in diameter. For smaller fireboxes, credit is to be allowed for their strength to resist collapsing pressure.

Rules for determining the proper allowance can be found in the Code. The maximum allowable working pressure for unstayed, riveted, seamless or lap-welded furnaces, where the length does not exceed six times the diameter and where the thickness is at least $\frac{5}{16}$ in., shall be found by one or the other of the following formulas:

A. Where the length does not exceed 120 times the thickness of the plate,

$$P = \frac{51.5}{D}(18.75T - 1.03L)$$

B. Where the length exceeds 120 times the thickness of the plate

$$P = \frac{4250T}{LD}$$

In these formulas,

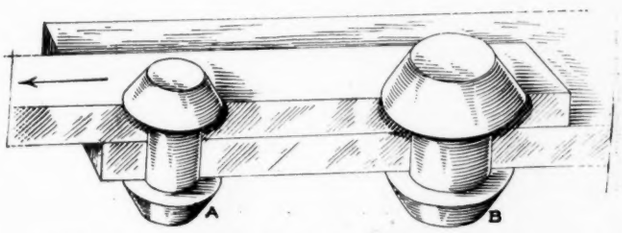
P = Maximum allowable working pressure, in pounds per square inch;
D = Outside diameter of furnace, in inches;
L = Length of furnace, in inches;
T = Thickness of furnace walls, in sixteenths of an inch.

To illustrate, take a vertical boiler fitted with a furnace made of $\frac{5}{16}$-in. steel, 36 in. outside diameter and 36 in. high. It is desired to carry 125 lb. pressure on the boiler. How many $\frac{3}{4}$-in. stays will be necessary?

The length does not exceed six times the diameter; that is, 36 in. is less than 6 x 36 in. Also, 120 times the thickness of the plate is 37.5 in., so that the length does not exceed 120 times the thickness of the plate. Hence formula A is applicable and

$$P = \frac{51.5}{36}[(18.75 \times 5) - (1.03 \times 36)] = 81\ lb.$$

The stays must then be designed to carry 125 — 81 = 44 lb. per sq.in. pressure on the sides of the furnace, or a total of $3.1416 \times 36 \times 36 \times 44 = 170{,}000$ lb. At 7500 lb. per sq.in. the allowable load on each $\frac{3}{4}$-in. stay having 12 V-threads per inch is 3142 lb. Hence, the number of stays required is $179{,}000 \div 3142 = 57$. Therefore use four roundabout rows of stays 7 in. apart, $7\frac{1}{2}$ in. from the top and bottom of the furnace and provide 14 stays equally spaced in each row. The stay-



LOAD HELD BY BOTH RIVETS AT THE SAME TIME

bolts should be arranged so that one stay in each row is close to the vertical lap joint in the furnace.

The A. S. M. E. Code also requires the pressure carried by the stays to be less than that given by the formula,

$$P = 112 \times \frac{t^2}{P^2} = 112 \times \frac{5^2}{8^2} = 43\ lb.$$

in which

t = Thickness of plate in sixteenths of an inch;
P = Maximum pitch in inches, which is approximately 8 in. for the case in hand;
112 = Constant depending on the type of stay.

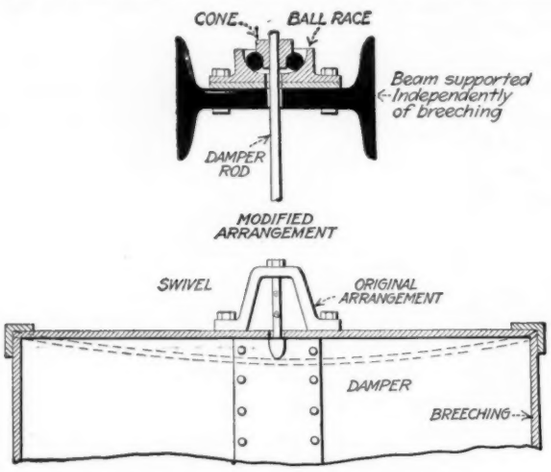
Hence the design satisfies the requirements of the Code in this respect also. Mr. Macdonald's general conclusion is evidently in error, as can be readily seen by applying it to any mechanical detail. Suppose, for example, that an iron strap is fastened to a heavy iron bar by means of two rivets as shown in the figure. The first rivet A is of such size that it will shear at 8800 lb., while the second one B will shear at 17,600 lb. The total force necessary to pull the strap off the block in the direction of the arrow is 8800 + 17,600 = 26,400 lb., so that the ultimate strength of the detail is 26,400 lb. and not 17,600 lb. as Mr. Macdonald's discussion would lead us to believe. The strength of the furnace plate is represented by the rivet A and the strength of the stay by the rivet B, the total strength to resist failure being the sum of the two.

HENRY F. GAUSS.

St. Louis, Mo.

Damper Supported on Ball Bearings

Some difficulty was experienced in the operation of a damper to which a regulator was attached, and the remedy adopted may be of interest to the readers of *Power*. The original support rested on the breeching,



IMPROVED SUPPORT FOR DAMPER

as shown, but when the breeching became hot it sagged slightly, allowing the damper to drag at the bottom. This was corrected by supporting the weight of the damper independently of the breeching, on a small I-beam, laid over sidewise, which kept it from dragging. To make the damper free-acting, a ball bearing was put on, made out of part of an old hub and ball race taken from a Ford car. The cone was secured to the rod that supports the damper. This gave a free-acting damper at very little expense.

Richmond, Va. JAMES M. PURCELL.

Devices for Care of Brushes and Commutators

Possibly one of the most disagreeable tasks that confront those who have the care of electrical machinery is

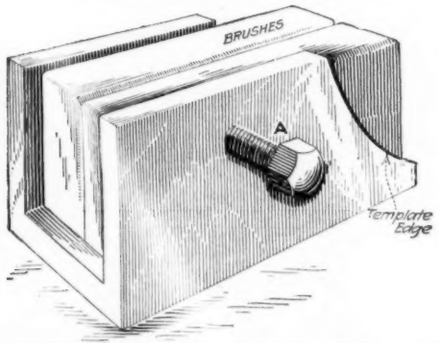


FIG. 1. TEMPLET FOR CUTTING BRUSHES TO SHAPE

that of sandpapering brushes. It is a dirty job, and any device that will eliminate some of its disagreeable features is generally welcome. The usual procedure in sandpapering brushes is, to put the brushes in the holders on the machine, insert a piece of sandpaper between the brush and the commutator and work the sandpaper against the face until a fit with the commutator is secured. Practically all brushes come from the factory with square faces and to cut them down to a surface fit on the commutator by the foregoing method is certainly some job.

I facilitated this work by making a holder for the brushes as in Fig. 1. This device is preferably iron, but if made of wood the templet edge can be of metal and attached to the holder.

The brushes are put in the holder and held rigidly by means of the screw *A*. A fine-toothed hacksaw is then drawn along the templet edge, cutting the brushes to shape. A smooth surface can be obtained by means of a piece of sandpaper laid over a file or block of wood, using the templet as a guide. The templet can be cut to the proper form by using an old brush as a guide, and when in use held in a vise.

When the brushes are put in the holders on the machine, it will be found that the major portion of the work has been done and to secure a good fit with the

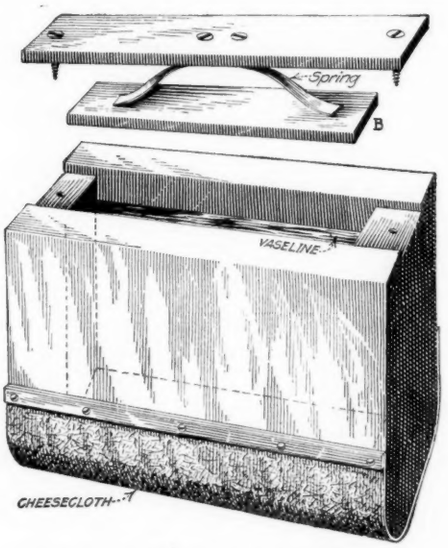


FIG. 2. COMMUTATOR LUBRICATOR

commutator only a few strokes of the sandpaper will be necessary.

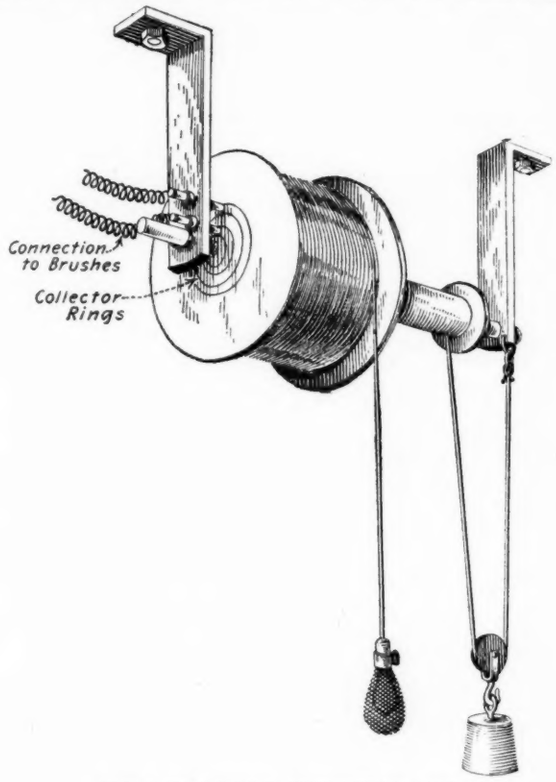
Proper lubrication of the commutator will do much to avoid the many troubles that arise from the wearing and cutting of the commutator and brushes. The practice of using a piece of oily waste as a lubricator often accentuates the trouble. I have found that vaseline sparingly used furnishes ideal lubrication for commutators. Fig. 2 shows the device I employ for applying the vaseline. It consists of a block of wood with a slot cut through it as indicated. One end of the slot is covered with cloth, preferably cheesecloth, arranged in a number of layers, so that each layer can be readily removed when necessary. The slot is filled with vaseline, which is pressed against the cloth by means of a spring cover arranged as shown at *B*. The heat of the commutator and the pressure of the spring will cause a sufficient amount of the vaseline to exude through the pores of the cloth to furnish the necessary lubrication.

Richmond, Va. JAMES M. PURCELL.

Adjustable Extension Lamp Cord

After trying out various methods of taking care of long extension cords that are used in and around grain elevators, we finally developed a reel that serves the pur-

pose admirably. By reference to the illustration it will be seen that the main part of the reel is made up of two large disks, of galvanized iron, separated by wooden slats to form a drum. On one side of this drum we fastened a fiber block on which were mounted two contact rings, and current is fed to these rings through a pair of brushes fastened to and insulated from the bracket that



REEL FOR LONG EXTENSION CORD

supports that side of the reel. On the other side of the drum there is a wooden cylinder, and a shaft extends through the whole. One end of a sash cord is fastened to the wooden cylinder; the other end is passed through a weighted pulley and fastened somewhat as shown. For a 100-ft. extension we find that the main drum should be about 16 in. in diameter by about 8 in. long, and the small cylinder should be 2 in. in diameter by 6 in. long. The extension cord is wound around the main drum, and the wires at the opposite end from the lamp were connected to the contact rings. As the extension is unreeled, the rope is wound up on the small drum. When the extension is released, the weight, which we found should be about thirty-pounds, unwinds the cord from the cylinder and the extension is wound up.

M. H. ERDMAN.

Minneapolis, Minn.

Soldering Wire Joints

It may be asserted without fear of contradiction that the majority of those who use solder have not an intelligent understanding of the materials they are using. It is not generally recognized that the soft solder commonly used for soldering copper wire has a resistance ten or twelve times that of copper, therefore it is advisable to get as good a copper contact in the splice as possible before soldering, and then use only the amount of solder necessary to cover the joint and prevent oxidization.

The harm done by acid soldering fluxes being left on a completed joint is in my opinion greatly overdrawn. Most cases of trouble in the joints of large wires will be found due to insufficient contact, causing the joint to heat. Small arcs may also occur in poorly made or improperly soldered joints. Sometimes an acid soldering flux is blamed for injury to small wire, when the trouble is due to burning the wire when the joint is being soldered. One good feature about an acid soldering flux is, if the metal surfaces to be soldered are not absolutely clean a good reliable contact will be made nevertheless, which cannot be said of some of the other soldering fluxes used. In my opinion mixtures containing zinc chloride are in every way superior to those containing ammonium chloride for a soldering flux.

Portsmouth, Ont. J. E. NOBLE.

Easily Made Oil Filters

Designing an oil filter is more a matter of "getting at it" and of the material at hand than of abstruse theory. A good sound oil barrel with a receiver, set into the head, as shown in Fig. 1, made of galvanized iron, or even an empty 25-lb. cup-grease can, will do good work. A pipe is attached, in any convenient way, to the bottom of the receiver and extended nearly to the bottom of the barrel, which is about half filled with water kept warm to expedite the action. The perforated bottom *B* in the receiver holds several thicknesses of burlap and some clean waste. Clean oil is drawn off

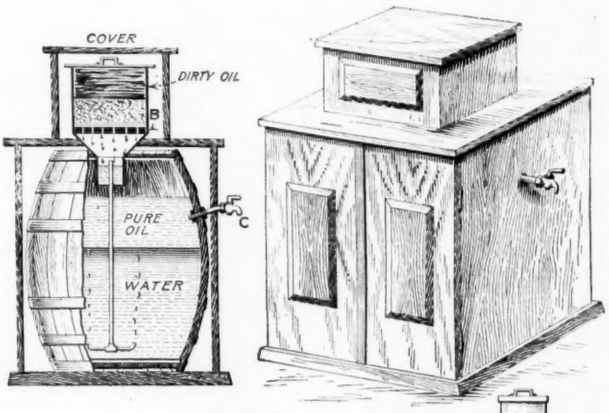


FIG. 1

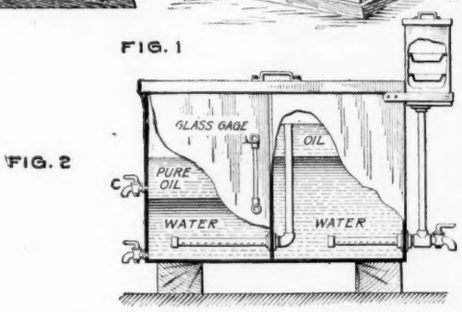


FIG. 2

TWO FORMS OF HOMEMADE OIL FILTERS

at *C*. The filter may be partly or wholly inclosed in a cabinet if desired, making it "respectable looking."

A little more elaborate filter may be made as shown in Fig. 2, of galvanized iron, and like the other one, will not require heating coils if kept in a fairly warm place. The construction is not complex, so that the illustration should make a detailed description unnecessary.

JAMES E. NOBLE.

Portsmouth, Ont., Canada.

The Fuel Administration's Attitude Toward the Isolated Plant

In reply to your criticism of the local committee of the United States Fuel Administration I desire to say that since its creation, the committee has done everything in its power to cut down the use of gas and electricity, and in justice to the gas and electric corporations who have coöperated with us, even to the extent of spending money in advertising to reduce sales and cut down their own revenue, I feel under obligation to protest against the pointed implications in your editorial in the issue of July 9.

I know of no general disagreement as to basic engineering facts. If you can point out any instance in which our committee, or anyone connected with the Fuel Administration within the district we cover, has advised or advocated the use of central-station service where there was use for the exhaust steam, or where the central station could not generate and deliver the current at lower fuel consumption than the isolated plant, I will give you my personal thanks for the information.

One of the chief possibilities which we had in mind was that of putting on central-station service, for the summer only, those noncondensing plants which have a heating load in the winter only. Of course our letter got to some plants where no saving was possible or practicable, because our information was not complete enough to make proper classification in every instance. We regret it, though we fail to see how harm could result, and we are greatly delighted and relieved to learn that the United States Fuel Administration is organizing a system whereby all plants will be more thoroughly investigated and assisted than our limitations made possible.

If the disinterested steam engineers, of whom you say "there are plenty," will volunteer their services in this important and immensely difficult task, I can assure you they will be welcomed, and we will undertake to see that they are put in touch with work which is worth while doing. If such men will help us in a constructive way, I venture to believe that the result will be as helpful in the present emergency as though they go into print with general criticism, based, possibly, on a misunderstanding of what we are doing.

EDWARD J. CHENEY, *Secretary*,
Albany, N. Y. Committee on Fuel Conservation.

Members of A. B. M. A. Able To Supply Boilers for Emergency Fleet

I note in your issue of July 16, page 105, a news item pertaining to an address made before this association on June 18, at Philadelphia, by Charles M. Schwab, Director General of Emergency Fleet Corporation. Your report of his statement that between eighty and ninety hulls were launched awaiting boilers, is correct. However, the next paragraph might be understood to mean that all boiler manufacturers had the orders in ample time and lacked capacity to build sufficient boilers for the needs of the Emergency Fleet Corporation up to this time.

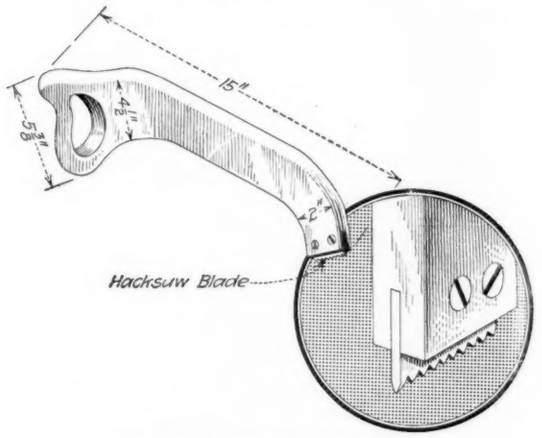
As that is not the fact in the case, I am writing to correct this impression. A very large part of the oldest and best-equipped plants have had orders for only a few (if any) boilers from the aforementioned department. Had all the business been well placed when the original order for about 900 boilers was given out nearly a year ago, the condition mentioned by Mr. Schwab would not exist today.

Promptly after his address, I asked Mr. Schwab to hear a committee of this association, and we expect to confer with him on his return from the Pacific Coast some time prior to Aug. 1. The old and well-established boiler manufacturers should be given an opportunity to demonstrate that they can meet this emergency. If they fail, it will be time enough to suggest that the Government finance the building of new shops for any one in the industry. In justice to the members of this association I feel called upon to send you this letter.

W. C. CONNELLY, President,
American Boiler Manufacturers' Association.
Cleveland, Ohio.

Tool for Undercutting Mica

To make a commutator groover, cut $\frac{3}{8}$- or $\frac{7}{16}$-in. fiber to the desired shape for a handle—the shape and size shown in the illustration has been found convenient.



COMMUTATOR-GROOVING TOOL

Saw a slot in the lower end to receive a short piece of hacksaw blade, which may be securely clamped in place with two bolts. The kind of saw, as to thickness and fineness, must be suited to the work.

Chicago, Ill. F. F. SENGSTOCK.

Correction as to Engine Economy

Regarding the economy of a small uniflow engine constructed by one of the professors at the Technical University at Delft, Holland, mentioned in my article on page 738 in the issue of May 21, I made the error of failing to convert the weight (7½ kilograms) of steam from metric units to pounds, by multiplying by 2.2, making approximately 16.5 lb. To correct the final result in the example used, the 6.4 deg. given as the rise in the feed-water temperature should therefore be so multiplied, making about 14 deg. F. rise in temperature. The line of reasoning of course remains unaffected.

Wageningen, Holland. Y. BROUWERS.

INQUIRIES OF GENERAL INTEREST

Connecting Draft Gages—Where would be the best place to connect U-tube draft gages for three horizontal return-tubular boilers set in battery? C. H.

The principal purpose of using a draft gage for each boiler would be to obtain information of the relative draft, and the best place for permanent connections would be the uptake of each boiler near its connection to the common smoke uptake.

Corliss Governor with Single Reach Rod—On an engine with a single reach rod from the governor, why is the crank-end valve set first? L. L. S.

When a single governor reach rod is used, it is connected to the cutoff cam of the crank-end steam valve and the cam of the head-end valve is operated by a rod connected to the cam of the crank-end valve. As the crank-end cam receives first motion from the governor, it should be adjusted first.

Cause of Failure of Corliss Cutoff—What would cause failure of cutoff of a double-eccentric Corliss engine? W. G.

Failure of cutoff might result from the same causes as in a single-eccentric Corliss engine. The governor may be so low that the projection of the cutoff cam is around to a position out of reach of the releasing gear; or the latches of the releasing gear may hang on from wear; or the dash-pots may not pull hard enough to overcome friction of the valve or valve-stem packing.

Drainage of Exhaust Pipe—What size drain pipe should be employed for the exhaust of a 20-in. x 48-in. steam engine? W. R. B.

A 1-in. drain pipe should be sufficient if connected near the engine and run with good pitch for not more than about 15 ft., with discharge against atmospheric pressure. For a greater distance the size of the drain should be increased to prevent back flooding from pipe friction. Such a drainage connection should be used at the foot of any riser and lowest point of any trap in the exhaust pipe.

Purposes of Compression—What are the main reasons for obtaining compression on an engine? F. N. C.

Compression of the exhaust is obtained for the purpose of filling the clearance spaces of the cylinder with exhaust steam compressed to high pressure, thereby avoiding the expenditure of live steam that would be required for that purpose at the beginning of the stroke. Compression of the exhaust is also employed to act as a cushion for overcoming the inertia of reciprocating parts of the engine so they may be brought to rest without shock at the end of the stroke.

Single and Double Shear of Rivets—What is meant by single shear and double shear of a boiler rivet? H. V. S.

A rivet is subjected to single shear when it extends through two adjacent plates that pull or push in opposite directions, tending to force part of the body of the rivet over the adjacent part, like the action of a pair of shears in producing cleavage at a single cross-section. A rivet is subjected to double shear when it extends through three adjacent plates, and the pull or push of the middle plate is opposite in direction to the pull or push of the others, tending to produce cleavage by shearing at two cross-sections of the rivet.

Longitudinal Shell Seams of Vertical Boilers—In vertical fire-tube boilers with circular water-leg fireboxes, why are the vertical seams of the shell opposite the firebox made with any less efficient form of joint than the vertical seams above the firebox? W. N. C.

The cylindrical form of the furnace wall is not considered to contribute any stiffness in resisting collapse, and the furnace wall is stayed as though it were a flat surface, by stay-bolts secured to the outer shell. The stay-bolts react radially and thus largely relieve the outer shell of hoop tension, so that the vertical seam at the firebox may be of considerably less efficient form of joint than the vertical seam in the shell above the firebox.

Taking Leads of Bearings—What is the purpose of taking a lead of a bearing and how is it performed? S. R.

Leads are taken to ascertain the amount of clearance of a bearing and to determine whether the bearing requires refitting. The method is to remove the cap and lay a length of lead wire along the cap or journal parallel to the axis. The cap is then screwed down hard on the liners and the lead wire is squeezed down to a thickness equal to the clearance. The lead thus affords means of gaging the clearance and, by comparison with a lead previously taken at the same part of the bearing, the difference of this thickness indicates the amount of wear that has taken place in the interval and the amount of clearance to be taken up in refitting the bearing.

Behavior of Corliss Cutoff with Overload—When a single-eccentric Corliss engine is overloaded, why does the point of cutoff jump from about half-stroke to nearly full stroke? J. V. O.

For the ordinary form of Corliss valve gear, with a single eccentric for operating both the steam and exhaust valves, the eccentric is on the line of dead points and the valves will have their greatest displacement when the crank has moved through 90 deg. less the angular advance of the eccentric and before the piston is at half-stroke. If the governor places a cam in such a position that the detachment gear cannot be released before the valve has received its greatest displacement, the detachment gear is returned over the cam without disengaging the valve. The valve then will remain under the control of the linkage connecting it to the wristplate, and it will not be closed until near the end of the stroke, when the cutoff will be determined by the lap and angular advance, just as with a plain slide valve.

Heat Balance of Boiler—What is the heat balance of a boiler and what is it based upon? H. W. K.

The heat balance of a boiler is a statement, similar to an accountant's balance sheet, giving a tabulation of the heat realized and the different losses sustained out of the heat that would result from theoretically perfect combustion of the fuel used. For better comparison of different performances, the values usually are reduced to the number of B.t.u. with which each item is chargeable per pound of fuel used and their respective percentages.

The data required for computing the items usually included in a heat balance are: Temperature of boiler room; temperature of escaping gases; ultimate analysis of the fuel; B.t.u. per pound of dry fuel; B.t.u. per pound of combustible; percentage of ash found by test; percentage of combustible in the ash; flue-gas analysis; and evaporation of the boiler from and at 212 deg. F. per lb. of fuel free of moisture. For example, if the heat value of the fuel were 14,460 B.t.u., the data might afford a heat balance per pound of fuel as follows:

	B.T.U.	Per Cent.
Heat absorbed by boiler	9,917	68.58
Loss due to moisture in coal	51	0.35
Loss due to moisture formed in burning H in coal	472	3.26
Loss due to heat carried away in dry chimney gases	2,367	16.37
Loss due to incomplete combustion of carbon	257	1.78
Loss due to unconsumed carbon in the ash	687	4.75
Loss due to radiation and unaccounted losses (balance)	709	4.91
Total	14,460	100.00

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

The Storage of Soft Coal*

By W. L. Abbott
Chief Engineer Commonwealth Edison Company

IT is popularly supposed that spontaneous combustion of coal is due to a sulphur content which rapidly absorbs oxygen when exposed to the air, and that the resultant heating gradually raises the temperature of the coal to the ignition point. More study of the problem, however, indicates that the only action of sulphur in the form of pyrite is to absorb moisture until the larger lumps of coal by mechanical disintegration are gradually reduced to slack. As this action occurs for the most part at the surface of the piles, it can hardly be the cause of fires which always originate at a depth of some feet. The real cause of heating is to be found in the oxidation of the coal itself.

Methods of preventing spontaneous combustion in piles of soft coal may be divided into two general classes—first, those in which air is excluded from the coal and, second, those methods in which sufficient air is circulated through the pile to carry away the heat generated.

Under-Water Storage

Under the first class would come under-water storage, where the protection is 100 per cent., but which usually has elements of cost and inconvenience that rule it out in all but special cases. By using sufficient care, coal can be piled so as to exclude air from the interior of the pile. To assist in keeping air away from the pile, it should be surrounded by a tight board fence or retaining wall, and to better exclude the air it is sometimes desirable to line the fence on the inside with tar paper.

In the inclosure coal that has been crushed is spread evenly and in successive layers, in some instances each layer being rolled to pack down the coal. In the process care should be taken not to form the pile from any one place, as in this case the coarser particles will separate out and roll down the side of the pile, leaving the fine coal at the center. This would create a porous section in the pile through which air could circulate to the fine coal, with the liability of starting a hot spot. It is evident that the deeper the pile the less danger of fire at the bottom, for the reason that the air is more certainly excluded.

In the other method of storing some of the agencies that may be employed to carry away the heat and thus keep down the temperature are cold weather, small piles and ventilation. Cold weather is almost always effective as long as it lasts, but it is not always available. Small piles are also effective, but this preventive cannot be made use of if a large pile is wanted. Ventilation is sometimes effective in keeping the temperature down and sometimes effective in fanning a smoldering fire. The safest and usually the most practicable way of storing coal in the open is to store only large lumps of coal.

The heating in coal piles is indirectly proportional to the size of the lumps. It depends upon the surface area exposed. It is possible to so select coal for two piles of equal tonnage that one pile will have from 100 to 1000 times as much lump surface as the other. It is this factor that is vital in successful coal storage. The larger the lumps the less the heating.

Selecting Sizes of Coal for Storage

In selecting the size of coal for storage certain practical considerations should be kept in mind. It would be possible to get coal in lumps weighing from 50 to 100 lb. With lumps of this size only, there surely would be no danger of heating, but the coal would be difficult to unload, still more difficult to load up again, and in the handling there would be so much breakage that there would be a dangerous amount of fine coal in the pile.

For general convenience and security the best coal to store is egg size, which has gone through a 6-in. screen and over a 1½-in. screen. This size of coal is suitable for most purposes and easy to handle. It is free from fine stuff and does not break up in handling. During the past ten years hundreds of thousands of tons of Illinois coal prepared in this way have been placed in storage in piles 25 ft. high, and in not a single instance has there been a case of serious heating.

The procedure previously outlined, if strictly followed, will guarantee the safety of a pile of coal against spontaneous combustion. The writer has had experience also in piling coal so that it will surely take fire if kept in storage during a few months of warm weather. The way to obtain this result is as follows: Select for the purpose mine-run coal, which will ordinarily contain about 20 per cent. of fine coal that will go through a half-inch screen. Handle this coal into storage with a crane. Drop each successive bucket of coal on the top of the pile already formed, for by doing so the fine coal will remain in the center and the coarse coal will roll down to the edge of the pile. When the pile is complete, the coarse coal will be around the edges of the lower part of the slope. In the center, all the way from the top to the bottom, will be most of the fine coal. There will be also a zone about halfway up the side of the slope where the coarse and fine coal are mixed.

In the central section of the pile the mixture is so well proportioned and so densely packed that air cannot circulate to support combustion. Along the outer surface on the lower part of the slope the coal is too coarse to heat, but at about the middle of the slope or higher up the voids between the coarse coal are part filled with fine coal and through the remaining portion of the voids air can circulate just freely enough to support the slow oxidation going on. It is along in this zone at a depth of from 5 to 8 ft. that the greatest heating occurs.

Intermediate Stages of Slow Combustion

Fire in a coal pile does not "break out"; slow combustion is in progress when the coal is being stored and it may increase or decrease as the weather becomes warmer or cooler, but before it gets into the condition where it might be properly said to be on fire, it goes through several intermediate stages. There will be a gradual warming up to a temperature of 130 to 150 deg. F. In cold weather coal at this temperature will give off a slight vapor. As the heating continues, the next indication will be an odor of coal gas. A week or two later smoke will appear, and after another week or ten days fire will be seen on the surface of the pile.

A pile of coal which has gone through one summer without excessive heating will be safe during coming years, so long as it is left undisturbed. The heating during the second and successive summers will never be as great as it was during the first summer, but if the pile is broken into or otherwise disturbed, the dangerous condition starts all over again. A certain pile containing 5000 tons of coal was moved from one yard and restored in another yard, and although it had remained for five years in its first location without heating, within two months after it had been stored in the second yard its condition was such that it had to be loaded up and sent to the boiler room.

Watching the Coal Pile

A pile of fresh coal, or one which has not gone through the heat of the summer, should be carefully watched for indications of heating during the first warm weather. This can be conveniently done by driving down into the pile from the top to the bottom a number of ¾-in. pipes. Temperatures are then taken by suspending in these pipes vials of water or of mercury, which can be drawn up to the surface, where their temperatures may be taken with a thermometer. The test pipes for each pile should be numbered and a record kept of the readings, so that curves may be plotted showing the changes of temperature at any particular depth in each of the pipes. These curves, plotted with reference to average outdoor temperatures, will give a

*From a paper presented before the National Firemen's Convention, Chicago, May 22, 1918.

reliable indication of the amount of heating that is going on.

It sometimes occurs that a local hot spot may develop in a pile, and in this case the danger may be removed by digging out the hot spot. If the heating is general and if it reaches the point where gas is given off, some heroic treatment is necessary, and the best treatment is to put the hot coal under a boiler without unnecessary delay. Where this cannot be done conveniently, the coal may be saved by spreading it out to a depth not exceeding 6 ft. and soaking it down thoroughly with water during the operation, or with a crane it may be transferred into a new pile of the same depth, thoroughly cooling it down with water during the repiling. By this means the coal may be kept from firing until the weather gets cooler or the coal can be taken from storage and burned.

A pile of coal that is heating can be nursed along for months by a liberal use of the hose, understanding, however, that in a pile of any depth it is seldom possible to put out a fire by merely pouring water on the coal, and once the use of water is begun it will be necessary to keep it up as long as that lot of coal remains in storage. A smoldering fire at some depth in a pile apparently cakes over and prevents water thrown on the pile from soaking down and reaching the under side of it. A 1½-in. pipe 10 or 12 ft. long, attached to the end of the hose and thrust into the pile, will effectively reach such spots.

If by any of the foregoing means the fire is once put out and the coal cooled down, that pile will be safe for all time. It will never again heat to a dangerous degree unless its temperature is raised by some external means.

Handling Coal in Storing

There are various methods of handling large quantities of coal in storage, most of which involve the use of gantry or locomotive cranes with clamshell buckets. At times some other means of coal handling are employed, but these are relatively slow and expensive. The first time the writer stored any considerable quantity of coal the method was to lay a switch track into the storage yard and throw the coal off the cars by hand until it became so high on either side that it covered the rails. The track was then graded up to the top of the coal and the process repeated, so that the last of the coal was unloaded from cars on the top of an 18-ft. pile. It was fairly expensive to put the coal into storage and more so to take it out, as the coal had to be shoveled by hand into wheelbarrows and run up an incline some 10 ft. high to a platform from which the wheelbarrows were dumped into coal cars. An improved method established later employed a belt conveyor which of itself not only transported the coal along the side of the pile, but elevated it into the cars.

The most convenient way of recovering coal from ground storage, where a crane is not available, is to use a wagon loader driven by an electric or gasoline motor. This device will perform both the shoveling and the elevating operations. It will not work successfully however, with a large size of coal. In yards where the coal piles are to have a height of 40 ft. or more and a width of 100 ft., the gantry crane is the only practicable equipment. Buckets large enough to hold five tons of coal are sometimes used, and with such a device 300 tons or more can be handled in an hour. These enormous piles are open to the objection that they are difficult to shift in case of fire.

Another method becoming standard in the West is to lay out a yard with parallel tracks arranged in pairs, the tracks of each pair being spaced 20 ft. apart and the pairs 100 ft. between centers. This permits a train of cars to be placed on one of the tracks, while locomotive cranes operating from the other track transfer the coal from the cars to the pile, or vice versa. It is easy to form coal piles 25 ft. high and 70 ft. wide at the base, a pile of these dimensions containing about 20 tons of coal per running foot. The Commonwealth Edison Co. has several coal yards laid out according to this plan, one of which, just outside the city limits, covers one-half of a forty-acre tract. It has five miles of railway tracks and can accommodate nearly 400,000 tons of coal. Hundreds of thousands of tons pass through this yard annually and during the last six years there has been no trouble from fires.

The Fuel Oil Situation*

By Alfred C. Bedford

Chairman Board of Directors of the Standard Oil Co. of New Jersey, Chairman of the National Petroleum War Service Committee

The topic under discussion is, "To What Extent Is Fuel Oil Likely To Be Used as a Substitute for Coal?" I wish I could encourage you and tell you that we could give you all the fuel oil in substitute for coal that you need; but we cannot do it. It is necessary to say the contrary—that you have to conserve fuel oil, not because we have not produced large quantities of it in this country, but because most of it happens to be in Mexico. Our own problem of production of oil is a strenuous one, and while we are doing everything to encourage and develop it, and have developed it, yet we must look for future supplies, especially of fuel oil, from Mexico. There is an unlimited amount of fuel oil in Mexico. The difficulty is in obtaining ships. We have given over 50 per cent. of our oil-tank fleet to the service of the Government, and those are running abroad.

The industry has put down for itself two propositions: First, that all our energy be devoted to the prosecution and winning of the war, and to that end we have supplied every gallon and every barrel of oil of any kind or nature that our fleet and the fleets abroad and our armies and the populations abroad have needed. Second, to take care of the industry itself. So far at home we have been able to do that. There was a shortage of fuel oil, especially in New England, during the winter, although that was not due to the fault of the oil companies, but entirely to bad transportation conditions. The same is true of coal, although not to the same extent.

We have arranged with the Government for a priority schedule composed of twelve items. There is one item for railroads, another concerning navy and war supplies, the next and largest one is public utilities, and then we get down to the plants engaged in the manufacture and production of munitions, etc., for war. We can take care of practically all plants covered within the priority list; but we are going to have very little over after that. About 30,000,000 bbl. will be consumed along the Atlantic Seaboard during the coming year, not to speak of the interior. Of this about 13,000,000 bbl. will be consumed in class 5, which covers the gas companies. The other great class which is taking a large amount of oil is the munition makers, who will take about 13,000,000 bbl. of fuel oil. Between these two, the 30,000,000 bbl. available will be used. Fuel oil should not be used under boilers, either stationary or locomotive. For metallurgical work in small forgings and in large forging furnaces, and those used for annealing and other purposes, oil has its essential place. Manufacturers should have storage facilities for fuel oil when they use it, so that at least 60 days' supply may be kept on hand.

The Army Studies Power Needs at Niagara Falls

Acting under orders from the Secretary of War, Robert J. Bulkley and Brig. Gen. Charles Keller of the Corps of Engineers have been exercising a general supervision over the supply of electrical power in that portion of western New York in which Niagara Falls hydro-electric power is used. This supervision has been in effect since November, 1917, and its first result was to cause the Secretary of War to requisition for the United States all power generated or imported by the Hydraulic Power Co. and the Niagara Falls Power Co., both of Niagara Falls, N. Y., and to distribute it to war industries.

Both companies affected obeyed loyally the orders issued Dec. 28, 1917, and since then have been disposing of all the electric power under their control in exact accordance with the instructions of the representatives of the Secretary of War. Other power companies not requisitioned have been coöperating in the plans, and this has resulted

*From an address before the spring meeting of the American Society of Mechanical Engineers, Worcester, Mass., June, 1918.

in the curtailment of the supply of power to many minor and non-war essential industries and the assignment of the power so saved to plants producing war essentials. During the past winter difficulties caused by ice or shortage of coal were met by cutting off all but the essential industries and by supplying the latter with power in order of preference indicated in the schedules accompanying the requisition orders.

As a result of supervision accurate knowledge has been obtained of the uses of power generated in this country in the Niagara Falls district and that imported from Canada. This information shows that practically all the power available is used to aid the prosecution of the war, direct war industries securing an average of 85.29 per cent. of the total power of the two requisitioned companies and an average of 54.29 per cent. of the total power of the coöperating companies. Under war conditions the power supply falls short of the demand by about 200,000 hp., which amount is not based on new industries but is determined as the amount which could be absorbed by the industries now operating were such a supply available.

Some of this shortage will be relieved by the proposed enlargements of the steam plants of the Buffalo General Electric Co. and the Niagara, Lockport & Ontario Power Co. Additions to these two plants will aggregate 62,000 hp. By means of a further development by the American hydro-power companies at Niagara Falls, their existing supply of power, amounting to about 250,000 hp., will be increased by about 160,000 hp. To make certain that the fuel supply of the important steam-power plants in this territory will be maintained, arrangements have been made to secure the early coöperation of the Fuel Administration to that end.

The increased allotments of power to the essential electrochemical industries in the Niagara district and to the plants devoted to the production of such essentials as ferrosilicon, electrodes, phosphorus, chlorine and abrasives have conclusively demonstrated the beneficial results of regulating and controlling the distribution of power.

As a result of Governmental studies, accurate knowledge was obtained of the uses of power generated in this country in the Niagara Falls district and that imported from Canada. This information shows that practically all the power available is used to the advantage of the prosecution of the war, as appears in Table I.

TABLE I.—USAGE OF ELECTRIC ENERGY AS PRODUCED DURING A TYPICAL PERIOD IN THE WINTER OF 1917-1918

	Niagara Falls Power Co.	Hydraulic Power Co.	Niagara, Lockport & Ontario Power Co. Niagara & Erie Power Co.	Buffalo General Electric Co.
	Percentage of Total Output			
Direct war industries	73.53	97.05	58.31	50.27
Transportation purposes	11.55	.....	21.21	21.47
Street, commercial and residence lighting, water supply	7.81	1.95	7.61	13.99
Commercial power consumers over 100 hp.	1.52	0.13	5.94	2.82
Small commercial power	3.61	0.78	6.80	7.49
Nonessential purposes	1.98	0.09	0.13	3.96
	100.00	100.00	100.00	100.00

TABLE II.—DISTRIBUTION OF ELECTRIC POWER OF THE HYDRAULIC POWER CO. OF NIAGARA FALLS, BEFORE AND AFTER APPLICATION OF ORDER OF THE SECRETARY OF WAR, DEC. 28

Name of Company Taking Power	Use of Power Nov., 1917	Reapportionment of Power Increase	Decrease	Distribution of Power March, 1918
	Hydraulic Power Company			
	Hp.	Hp.	Hp.	Hp.
Aluminum Company of America	65,866	.....	6,000	59,866
Ice companies	473	.....	223	250
Cliff Paper Co.	3,291	.....	3,291	0
Defiance Paper Co.	2,034	.....	2,034*	0
Frontier Brick Co.	36	.....	36	0
General Abrasive Co.	1,706	.....	.....	1,706
National Electrolytic Co.	2,892	.....	.....	2,892
Union Carbide Co.	37,000	5,500	.....	42,500
Hooker Electrochemical Co.	6,534	.....	.....	6,534
Isco Chemical Co.	591	600	.....	1,191
National Carbon Co.	2,477	2,184	.....	4,761
Niagara Alkali Co.	5,714	300	.....	6,014
Oldbury Electrochemical Co.	3,000	3,000	.....	6,000
United States Light and Heat Corp.	1,319	.....	.....	1,319
Titanium Alloy Manufacturing Co.	7,074	.....	.....	7,074
Other smaller companies	4,514	.....	.....	4,514
	144,621	11,584	11,584	144,621

*Later returned to paper company when it began manufacture of ferrosilicon.

TABLE III.—DISTRIBUTION OF ELECTRIC POWER OF THE NIAGARA FALLS POWER COMPANY, OF NIAGARA FALLS, BEFORE AND AFTER APPLICATION OF ORDER OF THE SECRETARY OF WAR, DEC. 28

Name of Company Taking Power	Use of Power Nov., 1917	Reapportionment of Power Increase	Decrease	Distribution of Power March, 1918
	Niagara Falls Power Company			
	Hp.	Hp.	Hp.	Hp.
Buffalo General Electric Co.	35,282	.....	9,100	26,182
Niagara River Manufacturing Co.	880	.....	880	0
International Paper Co.	3,000	.....	3,000*	0
Acheson Graphite Co.	5,408	2,500	.....	7,908
Hooker Electrochemical Co.	9,165	.....	.....	9,165
Isco Chemical Co.	709	.....	.....	709
Mathieson Alkali Co.	10,343	1,407	.....	11,750
Niagara Electrochemical Co.	9,506	4,000	.....	13,506
Niagara Alkali Co.	1,363	.....	.....	1,363
Oldbury Electrochemical Co.	2,654	.....	.....	2,654
Star Electrode Works	4,083	1,600	.....	5,683
Carborundum Co.	10,483	2,217	.....	12,700
Union Carbide Co.	16,533	1,256	.....	17,789
Other smaller companies	23,935	.....	.....	23,935
	133,344	12,980	12,980	133,344

*Later returned to paper company when it began manufacture of ferrosilicon.

Appeal to Department Force To Economize in Fuel

Owing to the possibility of coal shortage next winter, Secretary Redfield has appealed to the officers and employees of the Department of Commerce to employ all possible means to save coal. The appeal follows:

The fuel outlook shows the possibility of a shortage in the coming winter. Various conditions may, indeed, improve the situation, but there is, of course, a possibility of an adverse change. From any point of view the situation is one that calls for every possible effort on the part of the service under your charge in certain definite directions. These are: (a) The direct saving of coal in its use; (b) the use of wood where practicable to replace coal; (c) care in the use of electric lights and of gas; (d) special measures of economy.

(a) The Saving of Coal in Its Use—Careless and ignorant firing is responsible for the waste of much coal. Certain it is that if all coal users did their firing with care and intelligence millions of tons of coal would be available that are now wasted. See that directions are given to economize coal in every field station under your charge. He who fires a boiler wisely now may insure his wife and babies against cold next winter. Black smoke means poor apparatus or poor firing; in either case wasted money. He who makes 8 shovels of coal go where 10 went before serves his country well and helps win the war.

(b) The Use of Wood Where Practicable to Replace Coal—In and about some field stations in your care may be wood available for fuel and not suited to other use. This used as fuel saves coal and helps win the war. Let every effort be used to make wood that is only suitable for fuel take the place of coal. See that this is given primary and not perfunctory care.

(c) Care in the Use of Electric Lights and of Gas—See that in the buildings used by your service lights are not used before and after they are necessary. "Turn out the light" is always sound sense, but now has saving value. Use electric lamps of an economical size and kind. Some old types consume much more current than modern ones, particularly if lamps are old. The Bureau of Standards will advise you as to types. In many a closet, hall and other place where no reading is required small lamps do as well as large ones (a 15-watt may replace a 25-watt or a 40-watt). On the other hand, where much light is required, one lamp of fairly large capacity is more efficient than a group of small ones.

(d) Special measures of Economy—See that instructions are given not to open windows directly over radiators next winter if ventilation can be had any other way. It is easy

by carelessness in this respect to double the condensing power of a radiator, hence to make double demand upon the boiler, so wasting fuel. See that steam pipes are covered and that those already supposed to be covered are actually so. There may be places where kerosene can be used as fuel so long as the supply thereof is good. (Consult the Fuel Administration.) If peat can be had, use it where it will do. Let every officer in charge of a field station reckon himself responsible for aiding the Fuel Administration. It is his patriotic duty in this matter of fuel to help the country.

Washington Water Power Co.'s Valuation

At a joint meeting at Olympia, Wash., of the public service commissions of Washington and Idaho the value of the light and power systems of the Washington Water Power Co. for rate-making purposes was placed at $20,500,000. The street-railway systems of the company were excluded from the valuation. In the brief of counsel for the water-power company a valuation of approximately $30,000,000 was suggested, which included the street-railway systems. Counsel for the City of Spokane placed a valuation of $23,000,000 on the property, including the street-railway lines. The property of the railways is worth, according to the state engineer's appraisal, about $5,500,000. Eliminating the railway figures, the valuation determined upon by the joint commissions lies between that of the city and that of the company. The Washington public-service commission in its conclusions accompanying the valuation figures, finds that the investments of the Washington Water Power Co. were judiciously made, the construction of the power plant economically handled and the interests of the investors and the public protected. There was no overbuilding, and 85 per cent. of the development is now in use. No allotment is made of the proportionate share of the investment to the smaller cities served by the company. This will be done, the board ruled, when rate hearings are taken up, which will be in the near future or as soon as the time expires, for an appeal from the state's valuation figures which the company may take. The report further states:

We are satisfied that from now on all the continuous power capable of generation by all the plants will meet a ready sale, and to meet the growing demands it will be necessary to increase its units at Long Lake and make full use of the 144-foot head at Spokane.

The valuation totals of the company are as follows: Valuation for rate making, Washington and Idaho, $20,500,000; for Washington, $16,700,000; for Idaho, $3,800,000; market value, $22,500,000; historical or book value, $19,529,329; total paid in dividends, $9,366,287; capital stock, $20,000,000; amount of stock issued, $15,490,000; market value per share, $70; funded indebtedness, $6,377,000; notes, $2,670,000; present earning capacity, $2,000,000; needed to meet fixed charges, $1,497,000. Dividend rate on stock, 1 to 9 per cent.

Fuel Economy in Mill Power Plants*

By George H. Diman†

I know of no department in any manufacturing concern where there is as much avoidable waste as in the boiler rooms of manufacturing concerns in New England.

To get good results, the managers and engineers should coöperate. As an illustration: Some years ago I took charge of eight mills, four woolen and four cotton, under two different agents, with the understanding that I should make a saving without spending any money for new appliances. The first six months before I took charge it cost $36,327.30 to operate the steam plant; the production of cloth was 812,363 lb. Every six months the power-plant cost was decreased, and for the six months ending Nov. 30, 1884, the cost for operating the steam plant was $20,950 and the cloth production was 1,257,353 lb., this increase in output being due to the fact that more machines were running than when I took charge. The reduction of costs was accomplished entirely by systematizing the boiler plants and by the aid of the managers of the mills. The same antiquated equipment was used throughout this period.

If I were to hire an egineer to take charge of a steam plant, I should have the man examined to see whether he thoroughly understood the economical burning of coal and should be careful to see whether he had tact in regard to handling men. It costs nothing to say "Good morning" to the humblest employee, and it should be remembered that there is just as warm a heart under the ragged shirt as under the best broadcloth.

In all the fifty years that I have employed labor, I have never gone outside the mill gate to hire men—always promoting the men in the yard. This gives the men an incentive to work. As an illustration, the chief engineer at the Ayer Mills was formerly head fireman at the Wood Mills.

Firing Methods That Have Proved Successful

First, have the grates not over 7 ft. in length—6½ ft. would be better—as it is impossible, if the grates are longer than this, to keep the back end of the fire covered. Set the boilers no less than 4 ft. above the grates—5 ft. would be better. This insures a good combustion chamber. It will be noticed that the boilermakers have practically the same size of ashpit door with a 250-hp. boiler as with a 600-hp. boiler. This gives a great supply of air under the doors, but none in the middle of the grates. I should dispense with the ashpit doors, cutting away the boiler front the full width of the grates. This gives an even distribution of air underneath the grates.

Start with the fire 14 in. thick and try to keep it the same thickness through the day's run. Time firing is the best, and in our mills in Lawrence we adopted the system of firing every ten minutes, putting on the number of shovelfuls required to keep the fire the same thickness and maintain the power. From 5 to 6 shovelfuls of coal is plenty. It takes about four to five minutes for a man to coal one side of two boilers and level the other. This gives him five minutes to rest. The boilers should be run about 50 per cent. above rating. This insures a very hot fire. Firing one side at a time prevents smoke. We have 44 boilers at our Wood Mills. They fire one-half of these boilers at a time; that is, one side, and level the other side of the same boilers. When they have finished, the men on the opposite side start and do the same. Every man has a chair to sit in, and in a 10-hour run the men are on their feet about half of the time.

Use a good shaking grate, which keeps the fire free from ashes, and avoid slicing as much as possible, as this makes clinkers.

The dampers should be set so that the boiler farthest from the stack has the same draft. If the steam damper is used, adjust it so it cannot close tight. If operating dyehouses, utilize all the available heat units in the dyehouse and finishing departments. In one of our large mills, some years ago, the dyeing and finishing departments got behind with their work. To get the goods into the market, we stopped the mill, running nothing but the dyeing and finishing departments. When the mill was running full we used about 6000 hp. and burned 1000 tons of coal per week. This power was generated by two pairs of cross-compound engines, sacrificing on the vacuum, and keeping the discharge water in the condensers at 110 deg. All this water was stored in the finishing department in tanks for washing the goods. A simple engine of 2400 hp. furnished exhaust steam for use in dyeing.

When we ran two weeks with only the dyehouse and finishing room, we used direct steam and ran only one engine. It took 275 hp. to turn the shafting of the dyehouse, and we burned 775 tons of coal per week.

It will be seen that in the first case, where the heat units were utilized as far as possible, we got 6000 hp.; while in the other case, where direct steam was used, we got only 275 hp. and burned three-quarters as much coal as before.

*From a paper presented at the Fuel Sessions, spring meeting, American Society of Mechanical Engineers, Worcester, June, 1918.

†Consulting engineer, Wood Worsted Mill, Lawrence, Mass.

The first patent taken out for mechanical stoking was in 1785, and the inventor was James Watt.—*Engineering (London).*

Instruments for the Boiler Room*

The consensus of opinion seems to be that for power plants generally, the boiler rooms should not only be provided with numerous instruments, but these should be recording.

E. G. BAILEY:[1] Meters are divided into four general types: Those which show condition; total; rate; relation. Meters which show condition include pressure gages, thermometers, water-level gages, etc., which in a boiler plant are used to measure steam and draft pressures; steam, flue-gas and feed-water temperatures; water level in the boiler and other similar factors. These meters may be either recording or indicating.

Meters which give total values or quantities include coal- and ash-weighing or measuring devices, also integrator meters for water, steam, etc. These are usually indicating only. Meters which show rate can be either recording or indicating, and include boiler-feed, steam-flow, air-flow, stoker-speed, etc. They may also be combined with integrating meters of the second type.

One of the important relations desired is that between rate of steam generation and rate at which fuel is burned. With liquid or gas fuels of uniform quality this is possible; but with coal about the closest approach is the relation between a steam-flow meter and tachometer on the stoker drive. The latter, however, is a crude means of determining the rate at which the B.t.u. are supplied to the furnace, and this is the real factor desired. It is doubtful if this will be satisfactorily attained, in the near future at least, owing to the varying amount of coal fed per revolution of the stoker shaft and the varying quality of the coal, as well as variations in the amount of coal on the grate.

Relation of Steam Flow and Air Flow

Another relation analogous to the steam-fuel ratio that is readily obtained and of even greater value, is that between the rate of steam flow from the boiler and the rate of air flow which supports combustion for the generation of this steam. Air is a fuel just as much as carbon or hydrogen, and the amount of air required to develop a given number of B.t.u. is practically independent of the character or quality of coal being used.

Another important relation in boiler operation is that existing between flue-gas temperature and rate of steam output. While this relation depends upon the position of baffling and other features of design, it is perfectly definite for any one design, and a certain flue-gas temperature should exist for each rate of steam output.

The firemen and operating men must have meters which serve as eyes whereby they can see through steam pipes and brick walls, so to speak, and actually know what is taking place. The meters that will give them the true pictures in the most realistic and concrete form are the most useful in saving coal.

WALTER N. POLAKOV:[2] A plant of which it is not known how many pounds of coal are used per 1000 lb. of steam, how the load is distributed among the units and throughout the day, etc., by necessity wastes fuel. The knowledge of these data does at least open the eyes of those responsible for its success, and further progress is thereby made possible.

The first group of instruments thus comprises: Quantity—Recording coal scales, recording steam or water meters. Quality—Coal calorimeter and moisture scales, feed-water thermometer, steam-pressure gage and thermometer.

The second group of instruments is intended to direct the processes by controlling conditions: Conditions—Individual flow indicators, individual draft gages, individual flue-gas thermometers, flue-gas analyzer.

Substitution of flow indicators by coal or oil meters is undesirable, as it leaves obscure the output for given input; draft gages may be substituted by pitot tubes. Other modifications are sometimes desirable, but the foregoing equipment is necessary and sufficient in general cases.

Any investment in instruments is a pure waste of money, and leads to demoralization unless means are provided for training men to properly use them, stimulating men in the proper use of them, complete, exact and continuous recording.

Location and arrangement of instruments should be such as to permit simultaneous readings and their comparison, permit plain view of units from instrument board and vice versa, afford the opportunity to use one instrument for diverse units, eliminate unnecessary fatigue of observing scattered instruments and assure ease and simplicity for testing.

These requirements are combined in the type of instrument boards devised by the author.

Complete cost of installation, including the labor and material, averages $2000, and the returns secured on this investment are usually equal or better than told in the following report from a plant using from 150 to 250 tons of coal per week.

. . . it is evident that in the four months preceding the installation of the boiler-control board the savings on fuel, due to various steps taken, averaged $435 per month, while in the four months following the installation of the instruments the savings computed on the same basis averaged $1145. In other words, the increased savings due solely to the intelligent use of instruments on the boiler-control board was $710 per month, or $8520 on the annual basis, which means that the expenditure of $2080.46 for instruments of the board is an investment which, in our case, yields over 400 per cent. return.

A fallacy of economizing on instrument equipment or ignorant attempts to select "the most important" ones has only one rival in absurdity—the tendency of installing instruments without giving the employees the opportunity to use them to advantage. Obviously, the operating men have no time, no ability for research work, and little inducement to carry out investigations, standardize methods, and set tasks. It should be the duty of the management to give them the necessary training and to assume responsibility for results.

*From papers contributed to the Fuel Session, spring meeting, American Society of Mechanical Engineers, Worcester, Mass., June, 1918.

[1]President, Bailey Meter Company, Boston, Mass.

[2]Consulting Engineer, New York City.

Availability of Natural Gas as Fuel*

BY ROBERT H. FERNALD† AND SAMUEL S. WYER‡

ROBERT H. FERNALD: There seem to be three obvious fields: (1) For extensive power production at the mines; (2) as a substitute for natural gas for general heating purposes; (3) in conjunction with byproduct coke ovens.

1. In the field of power production through the internal-combustion engine the application of the gas producer seems limited to plants of relatively small capacity. This is due to the fact that practical size limit for gas engines seems to be not over 5000 hp., and very few engines of this size are built.

The gas-engine gas-producer combination can hardly be considered the central-station service. For large power installations the natural development is the byproduct producer-gas plant located at the mines in conjunction with steam boilers and steam turbines. The low efficiencies due to the two-step conversion—first, gas generation from the coal and, second, burning of the gas under steam boilers—may be counterbalanced by the development of highly efficient boilers equipped for gas burning, and by the return from the valu-

*From papers contributed to the Fuel Session, Spring Meeting, American Society of Mechanical Engineers, Worcester, Mass., June, 1918.

†Professor of Dynamical Engineering, University of Pennsylvania.

‡Consulting engineer, Columbus, O.

able byproducts secured from the coal. Should the development of the gas turbine result in commercial units that compare favorably with the present large steam-turbine units, additional marked economies may of course be looked for.

2. The depletion of the supply of natural gas in many regions is leading to the gradual substitution of producer gas in place of natural gas,—using producers of either the by-product or non-byproduct type.

3. This field embraces two divisions; (a) one in which there is an unlimited demand for the coke from the ovens as well as for the gas and byproducts; (b) one in which there is no market for the coke, but a ready market for the gas and byproducts.

a. This type of plant is composed essentially of two distinct installations, a byproduct coke plant and a byproduct producer-gas plant. The entire gas output of the coke plant may thus be made available for the market, as the lower heat-value producer gas may be used for heating the coke ovens. One of the advantages of this system lies in the fact that coke breeze and low-grade fuels may be used in the producers. In a large European plant of this type the coke oven gas is the main product and the coke, which finds a ready market, is regarded as one of the byproducts. The byproducts from the producer-gas plant, sulphate of ammonia and pitch, practically pay the cost of operation of this portion of the installation.

b. In case there is a demand for the byproduct coke-oven gas but no convenient market for the coke, the natural step involves placing gas producers in close contact with the by-product coke plant, feeding the coke directly into these producers. Such portion of the producer gas as is not used for heating the coke can be mixed with the byproduct coke-oven gas for general distribution.

Developments along the three lines indicated seem to offer attractive possibilities, and their adoption on an extensive scale would lead to economy in fuel consumption.

SAMUEL S. WYER: The natural-gas industry is in a transition stage, changing from the large-volume, low-price-per-unit basis, to the relatively small-volume and larger-price-per-unit basis. The reasons why natural gas cannot and ought not to have an extensive use for steam boiler work in the future may be enumerated as follows:

a. The number of domestic consumers, now over 2,363,000, is increasing much faster than the number of producing wells.

b. The initial production and the routine available production coming in are much lower than for wells that came in five years ago. This is due to the general depletion of existing fields and the extensive underground drainage from past production.

c. New fields are not being discovered fast enough to replace the rapidly declining present supplies.

d. The general shortage of coal for domestic heating in the past and the inevitable continuance of this condition for some time in the future, at least during the period of the war, has placed enormous additional demands for domestic heating on the natural-gas resources where natural gas is now and will be used in lieu of solid fuels for heating homes.

Natural gas is preëminently a domestic fuel. Its high heating value, practically twice that of any manufactured gas available, its purity, and ease in handling make it the premier fuel for home use. While low-grade solid fuels can be efficiently used under steam boilers with proper stoking equipment, they cannot be satisfactorily or efficiently used for house heating. For this reason it is a matter of conservation to use the fuel for domestic service that in the long run will yield the greatest good to the greatest number.

The tests recently made in the Home Economics Department of the Ohio State University on cooking various meals with natural gas, soft coal, coal oil, gasoline and electricity, show conclusively that natural gas is by far the cheapest fuel for the domestic consumer's use for cooking. Thus, in cooking a dinner for six people, the total fuel costs, with natural gas at 40c. per 1000 cu.ft., soft coal at $6.50 per ton, coal oil at 15c. per gal., gasoline at 27c. per gal. and electricity at 3c. per kw.-hr., were as follows: Natural gas, 0.88c.; soft coal, 2.5c.; gasoline, 4.6c.; electricity, 5c.; coal oil, 5.4c.

The rendering of domestic natural-gas service is a public-utility business. Practically all of the states where natural gas is now produced and sold have public-utility commissions with broad powers on matters of rate regulation and quality of service. The general tendency, and the one that is in accordance with sound public policy, is to give the domestic consumer first preference and curtail the consumption of natural gas for industrial purposes. For the reasons given in the preceding paragraphs, it may be reasonably expected that this tendency will become more marked in the future and public-utility regulations regarding the use of this best of all of nature's fuels for domestic service, will become more exacting and ultimately will result in the very great curtailment of steam-boiler and other industrial natural-gas users.

Meeting of Boiler Code Committee A. S. M. E.

The following letter, calling attention to the forthcoming meeting of the Boiler Code Committee of the American Society of Mechanical Engineers, has been sent to the members of the committee:

For the meeting of the Boiler Code Committee scheduled for the latter part of the month to bring the revision work to a close, the date of July 31 has been tentatively selected in view of the extreme urgency that the work be completed immediately. Will you kindly advise if this date will be convenient for you to attend the meeting?

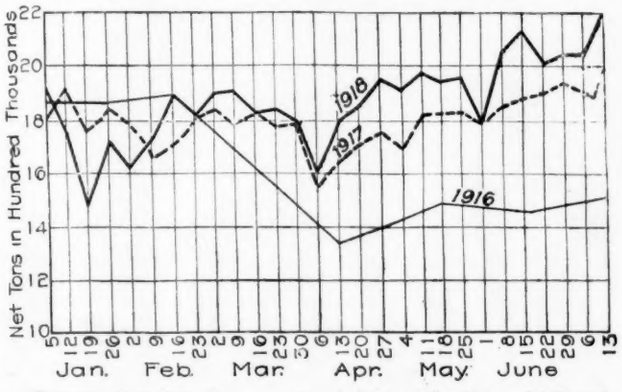
The early completion of the revision work is imperative, first, of course, because the States of Ohio and Pennsylvania are proceeding immediately with the printing of their new Codes which will embody our proposed revisions as contained in the printer's proof sent you on the 15th; second, because the Canadian provinces are to hold a conference in Winnipeg, Man., on Aug. 5, to discuss plans for uniform code rules in Canada, and it is most desirable that our new schedule be submitted to that conference in complete form; third, because the public is bringing great pressure to bear upon us for the new edition. The chairman urges a full attendance at this meeting, and we trust that every member of the committee will recognize the importance of immediate and decisive action.

C. W. OBERT,
Secretary to the Committee.

Lightless Nights Again

On Wednesday, July 24, the resumption of "lightless nights" became effective. All outdoor illumination, with the exception of necessary street lighting, was ordered discontinued after that date on Monday, Tuesday, Wednesday and Thursday of each week in the New England States, New York, Pennsylvania, New Jersey, Delaware, Maryland and the District of Columbia, and on Monday and Tuesday of each week in the rest of the United States.

The regulations are the same as those of last winter, with the exception of the nights designated.



Curves showing the average total production of bituminous coal per working day for corresponding periods in three years. Ten more weeks of production equal to that of the week ended July 13, or 13,243,000 tons, will make up the deficit of the coal year from Apr. 1 to date.

Delegates to the N. A. S. E. Convention

"Who was the gentleman I met at the convention who interested me about his record-keeping system?" "Darn! What was that man's name?" or "I wish I could recall his face." To help delegates to remember the new acquaintances made during convention week *Power* will give each delegate a package of business cards, each card bearing

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NEWARK, N. J., No. 3. N.A.S.E.

his photograph. To insure getting his cards each delegate should mail his photograph—the three-for-a-quarter post-card size, head and shoulders only will do—his name, business connection, address and association number to F. R. Low, Editor, *Power*, 10th Ave. at 36th St., New York City. Do it now and make it sure for you and easy for us. A facsimile of one of these cards is shown herewith. If your photograph, name, etc., reach us early enough your cards will be ready for you at the *Power* booths when the convention opens.

Wreck of Steam Turbine

At 5 p.m., July 20, 1918, a small Westinghouse impulse turbine, used for driving the condenser pumps for a 10,000-kw. turbo-alternator, was totally wrecked at the plant of the Connecticut Light and Power Co., Waterbury, Conn. This machine, which was installed about two years ago, drove its load through a reduction gear running at 3500 r.p.m. and had always been subject to excessive vibration. At the time of the accident it had just been repaired by putting in an old shaft and a rotor which was newly bladed and fitted with new bearing. When started up for a trial run, it ran for about five minutes, then began to vibrate violently. The operator immediately shut off the steam, but before the machine could come to rest the shaft broke where it entered the hub of the rotor on both sides. The rotor flew through the casing and after traveling back and forth a half dozen times between the concrete foundation walls, ran down a passageway, stopping about fifty feet away. The rotor disk was not broken, but the shaft was badly twisted and the casing bearings and coupling and governor were all smashed.

A road man from the manufacturer was badly cut by flying splinters, and one of the operating force was knocked down by one of the bearing caps, but no one was severely hurt. Examination of the shaft seemed to indicate that it had become crystallized by vibration and was unable to stand up under the high speed.

Shipping Board Engineering School at Pratt Institute

In Pratt Institute, Brooklyn, the United States Shipping Board Recruiting Service opened on Wednesday evening, July 22, its eleventh free marine-engineering school and its forty-fourth free navigation school for the training of experienced men as engineer and deck officers in the merchant marine.

The schools are not for landsmen. Men experienced in seafaring or engineering are eligible to enter these free schools, if they are American citizens over 19. The first aim of the Shipping Board's free schools is to help a man get his first license, and thus establish him as a licensed officer in the merchant marine; but the schools are also open to licensed men who wish to brush up on their navigation or mechanical knowledge as a step toward an advance in grade. Men trained in these schools will not be called for military service while in the merchant marine. Application for enrollment may be made at the schools, or direct to headquarters of the Shipping Board Recruiting Service, Custom House, Boston, Mass.

Combustion Engineers Wanted

The Bureau of Oil Conservation, Oil Division, United States Fuel Administration, is desirous of securing a combustion engineer for each of the following districts, who will act as an inspector, visiting all plants within his district using fuel oil and natural gas: Boston, Providence, New York City, Philadelphia, Pittsburgh, Buffalo, Detroit, Chicago, Minneapolis, Tulsa, New Orleans and San Franscisco. It is desirable to have these men act as volunteers where possible, but the Administration is prepared to pay a reasonable compensation for men who cannot afford to give their services to the Government. Only those who have had experience in fuel-oil and natural-gas combustion would be of value.

D. W. Cooke, Fuel Administrator for New York

D. W. Cooke, vice president of the Erie Railroad, has been appointed fuel administrator for New York State.

The Washington statement also announced that Charles E. Robertson, at present deputy state administrator, and Reeve Schley, administrator for New York County, had been named as Mr. Cooke's assistants.

The new administrator stated that he would confer with Mr. Wiggin, his predecessor in office, and also with Messrs. Robertson and Schley. He said:

At present I do not feel that I am sufficiently posted on the work to outline any plans or make any suggestions to the people of New York as to how we can avoid a coal shortage. I will say this much, however: I went around the harbor with Dr. Garfield yesterday, inspecting the terminal facilities for handling coal, and was much gratified to see that the railroads are already enlarging their steam-heating plants for thawing out frozen coal. The lack of these facilities gave much trouble last winter.

For 23 years Mr. Cooke has been with the Erie. His work on that road, which is an important coal carrier, has given him abundant means of studying the coal problem.

Government Control of Turbine Industry

By order of the Federal Government the War Industries Board will hereafter supervise the filling of orders for turbines of over 700 hp. Manufacturers of turbines under 700 hp. are not affected. The twenty-one manufacturers that come under Government supervision have agreed not to fill orders for turbines in excess of 700 hp. for either civilian or Government purposes, except for ships for the Navy and the Emergency Fleet Corporation, without a permit from the War Industries Board. Permits for filling of private or non-war orders will be granted only by the board when necessity is shown. The only exceptions to Government control of turbines rated above 700 hp. are for propelling equipment for the Navy and the Emergency Fleet, and do not include land types. Orders for the former may be placed direct and delivered.

The city lighting commissioner of Cleveland, Ohio, has asked the board of control to authorize an increase of 10 per cent. in power rates, with the assurance that lighting rates will not be affected. On the other hand, business organizations in Milwaukee, Wis., and Muskegon, Mich., are fighting strenuously in opposition to proposed increases in power and lighting rates in those cities.

New Publications

AIRCRAFT MECHANICS HANDBOOK. By Fred H. Colvin. Published by McGraw-Hill Book Co., Inc. New York, 1918. Leather, 5 x 7¼ in.; 402 pages; 193 illustrations. Price, $3.

The activities of the air fleet on the battlefronts of Europe have created unusual interest in airplanes in this country. This applies not only to those who aspire to become aviators, but to thousands of mechanics of various kinds who may desire to enter the service as airplane mechanics, who must know how to inspect, adjust and repair the huge fleet of airplanes which will be used by the American fliers "over there." The "Aircraft Mechanics Handbook" should be of great assistance to such men because it has been compiled for those who are interested in the construction and care of airplanes. The volume represents what is believed to be the best practice known at this time and contains many suggestions that will be of value to any aircraft mechanic.

The book begins with the general construction of airplanes, and the theory of how and why they fly. An entire chapter is devoted to the propeller, in which its construction is followed out in detail. Although the wiring of a plane might appear to be a simple matter, the chapter dealing with that part of its construction shows that there are many points to consider and that it requires an expert to properly do the job. Much also depends upon the wood used in the construction, as explained in the text devoted to that subject.

Naturally, the engine claims the greatest space devoted to any one subject. No attempt is made to go into the design of the engine to any great extent, but enough data are given so that the reader will get a comprehensive idea as to the difference between the various types that are discussed. The particular engines dealt with are the Curtiss, Hall-Scott, Sturtevant, Thomas-Morse, Gnome and Hispano-Suiza, and the Liberty airplane engine. Valuable data are given on the operating details and troubles to which the engines are susceptible, and how to overcome them.

Various types of airplanes are dealt with, ranging from the training type to the bombing and fighting planes. The volume probably contains more practical information regarding airplanes than any other that has been published.

BUREAU OF CHEMISTRY CIRCULAR AND CHART

The Bureau of Chemistry, U. S. Department of Agriculture, has recently prepared and issued for free distribution a popular circular and a mill and elevator poster in connection with the grain and dust explosion prevention campaign. This circular, entitled "Prevent Grain Dust Explosions and Fires," may be obtained by addressing the Bureau of Chemistry, Washington, D. C.

Obituary

Charles Allis, aged 65, second son of the late Edward P. Allis, founder of the E. P. Allis Co., died July 22, of pneumonia, following a serious operation, at his home in Milwaukee, Wis. After the consolidation of the Allis, Fraser & Chalmers and the Dixon Companies, Mr. Allis was the first president, remaining for a short period in this capacity. In 1889 he founded the Chicago Belting Co., and up to the time of his death was president. Mr. Allis was trustee and member of the executive committee of the Northwestern Mutual Life Insurance Co., a director of the First National Bank and the First Trust Co., of Milwaukee. Since the beginning of the war he has given most of his time to the Milwaukee County Council of Defense. His death came as a shock to a host of friends in Milwaukee and Chicago, where his interests centered. Mr. Allis is survived by his widow.

Personals

John H. Honey, assistant engineer in the Hill Building, McGraw-Hill Co., Inc., publishers of "Power," has accepted a position with the Edison Illuminating Co., of Brooklyn, N. Y. Mr. Honey will be engaged in construction and erection work and later in plant operation.

James D. Taylor, who was for many years connected with the Twenty-third Street Young Men's Christian Association as chief engineer and superintendent and consulting engineer to the Board of Directors of the City Associations, has resigned to accept the position as chief engineer and assistant superintendent of the Metropolitan Museum of Art, Fifth Avenue and 82nd St., New York City.

Garrett O. House, superintendent of the St. Paul City Railway company and former general manager of the St. Paul water department, has been made manager of the H. M. Byllesby & Company interests in St. Paul. Mr. House succeeds P. T. Glidden, former manager, who died recently. H. M. Byllesby & Company control the Minneapolis General Electric company and extensive plants and power equipment in St. Paul as well as throughout the Northwest and in other sections of the country.

Arthur H. Young, director of the American Museum of Safety since Jan. 1, 1917, has resigned to take charge of the Employee Relations Department of the International Harvester Co. Although giving up the actual direction of the museum's work, he will continue to be closely concerned with its affairs, as he has been elected to the vice presidency, succeeding the late Dr. Frederic R. Hutton. In recognition of Mr. Young's accomplishments as chief safety expert of the Federal Government, the Museum has just awarded him the Louis Livingston Seaman medal. His successor is R. M. Little, formerly a trustee of the museum. Chester C. Rausch has become connected with the Museum as assistant to the director. He was acting as chief safety engineer of the Navy Department, Bureau of Docks and Yards, at Washington, when called to the Museum of Safety.

Miscellaneous News

The State Steam Boiler Inspector for Allegheny County, Pennsylvania, Charles H. Garlick, has prepared, and is mailing to each boiler owner in the county, a circular giving valuable instruction in fuel conservation. Mr. Garlick's office, 804 Bessemer Building, Pittsburgh, has a complete record of every boiler operated in Allegheny County, and will advise, when requested, without charge, on any subject pertaining to steam-engine economy or the safe operation of boilers.

Patent Office Needs technically trained persons for the examining corps. Men or women are desired who have a scientific education, particularly in higher mathematics, chemistry, physics and French or German, and who are not subject to the draft for military service. Engineering or teaching experience in addition to the above is valued. The entrance salary is $1500. Examinations for the position of assistant examiner are held frequently by the Civil Service Commission at many points in the United States. One is announced for Aug. 21 and 22, 1918. Details of the examination, places of holding the same, etc., may be had upon application to the Civil Service Commission, Washington, D. C., or to the Patent Office. Should the necessity therefor arise, temporary appointment of qualified persons may be made pending their taking the Civil Service examination. Application for such appointment should be made to the Patent Office.

Business Items

The Hunter Pressed Steel Co. has moved from Orthodox and Horrocks Sts., Philadelphia, into its new office and works at Lansdale, Penn.

The Lagonda Manufacturing Co. announces the removal of its Kansas City branch office from 314 Dwight Building to 306 Elmhurst Building. F. H. Penberthy is in chrge as district sales manager.

Trade Catalogs

The Uniflow Boiler. Uniflow Boiler Co., Inc., Philadelphia, Penn. Buiietin 18. A general illustrated description of the boiler with table giving the horsepower rating of Uniflow boilers.

Oil Burners and Oil Burning Systems. Staples & Pfeiffer, San Francisco, Cal. Catalog No. 18. Pages 48, 6 x 9¼ in.; fully illustrated. Contains a vast amount of useful engineering data.

Rego Welding and Cutting Apparatus. The Bastian-Blessing Co., Chicago, Ill. Pages 29, 7⅞ x 10½ in. Describing and illustrating a complete line of welding and cutting torches and regulators.

New Construction

PROPOSED WORK

Mass., Newburyport—The Newburyport Gas and Electric Co. plans to build a power plant. Estimated cost, $10,000,000. C. S. Spaulding, supt.

Conn., Hartford—Swift & Co., 450 Church St., plans to build a cold storage plant.

Conn., Middletown—The Middlesex Hospital will build a 4-story hospital, and will also install a heating plant.

Conn., New Britain—Hart & Hutchinson Co. plan to install a new steam heat system in its 1-story factory to be erected on Corbin Ave.

N. Y., Brooklyn—The Board of Education plans to install a heating and power plant in the new 5-story school to be erected on Baltic and Henry St. C. B. J. Snyder, 59th St., Park Ave., New York City, Arch.

N. Y., New York—(Borough of Bronx)—W. Connell, 1001 Intervale Ave., plans to install steam heating system in connection with the proposed 2-story garage, and will be in the market for boilers as soon as the plans have been approved. J. J. Dunnigan, 391 East 149th St., Arch.

N. Y., New York—Bloomingdale Bros., 59th St. and Lexington Ave., plan to extend heating system, in connection with their proposed 1-story addition.

N. Y., Utica—The Oneita Knitting Mills, Broad St., plans to build a 1-story, 40 x 40 ft. power house addition. Estimated cost, $10,000.

N. J., Pompton Lakes—City will receive new bids in August, for a brick and concrete power plant to be erected near Pompton Lake Dam. The equipment includes turbine engines, electric switchboard, etc. Estimated cost, $56,000. Former bids rejected. Noted June 25.

Penn., Hazelton—Hotel Loughran plans to build a boiler house.

Penn., Philadelphia—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will receive bids until Aug. 5 for an extension to the boiler plant and heating system in emergency barracks. Estimated cost, $130,000. A deposit of $10 is required for the plans and specifications.

Md., Indian Head—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will receive bids until Aug. 5, installing boilers and superheaters in the nitrate plant. Estimated cost, $200,000. A deposit of $10 is required for the plans and specifications. Noted July 23.

D. C., Wash.—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will receive bids until Aug. 12 building a power house at St. Juliens Creek, Va. Estimated cost $7500. A deposit of $10 is required for the plans and specifications. Noted June 11.

Va, Norfolk—Baldwin Bros., Brooke Ave., has awarded the contract for the erection of a 6-story, 80 x 213 ft. building and will install a steam heat system in same to cost, $18,000.

Ohio, Cleveland—The Board of Education plans to install a low pressure steam heat system, boilers and radiation in the proposed 1-story school to be erected on Harvard Ave.

Ill., Great Lakes—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will receive bids until Aug. 5, building a mess hall and power house. Estimated cost, $200,000. A deposit of $10 is required for the plans and specifications.

Ohio, Hamilton—H. Ford & Son, Highland Park, Mich., plans to build a hydro-electric plant here in connection with a large factory.

Iowa, Mason City—The Board of Education will remodel the university building into a school and plans to install a heating plant. J. H. Felt & Co., Mason City, Arch.

Kan., Baxter Springs—The Cook & McCullough Mining Co. will install air compressors, boilers, etc., in its proposed new concentration plant. W. McCullough, Supt.

Kan., Baxter Springs—The Euterpe Mining Co., is in the market for conveyors, etc., for its new 200 ton mill. C. Clark, Supt.

Kan., Hillsboro—Tabor College plans to build a boiler room in connection with its proposed 3-story college building. W. Mampe, 559 Sheidley Bldg., Kansas City, Arch.

Neb., Palmer—The city voted $40,000 bond issue for the erection of a water and light plant.

Mo., Granby—The Carolyn Metal Co., Oklahoma, Okla., plans to install additional air compressors, etc., in the new addition of its mill. A. Darling, Supt.

Mo., Joplin—The Badger Mining Co. plans to install an engine, boilers, etc., in its proposed concentration plant. A. Foster, 401 Miners Bank Bldg., Supt.

Mo., Joplin—The Rashgo Mining Co., Sunnyside, plans to install air compressors, etc., in its proposed concentration plant. W. M. Randall, Supt.

Mo., Seneca—The Mt. Nebo Lead and Zinc Co. will install air compressors, boilers, engine, etc., in its proposed new concentration plant.

Mo., Waco—The Blue Rock Mining Co. plans to install air compressors, and boilers, etc., in its proposed concentration plant near here.

Mo., Waco—The Crescent Lead and Zinc Co. plans to install engines, boilers, air compressors, etc., in its proposed concentration plant. L. H. Falley, Supt.

Ark., Batesville—The Vance Mining Co. plans to install an engine and boiler in its proposed plant. C. H. Plumb, Miners Bank Bldg., Supt.

Ark., Harrison—The Harrison Mining and Milling Co. will install air compressors in its proposed new mill to replace burned structure. G. Constant, Supt.

Ark., Mountain Home—The Mattie May Mining Co. plans to install boilers and air compressors, etc., in its proposed 150 ton concentration plant.

Okla., Ardmore—The city plans to build a new pumping plant and install an engine. Mackintosh & Walton Co., Oklahoma, Engr.

Okla., Oklahoma—J. W. Reems and J. G. Sackett, plans to install air compressors, boilers, etc., in its proposed concentration plant to be erected at Spring City near here. J. W. Reems, Supt.

Okla., Miami—The Zuni Lead and Zinc Co. plans to install air compressors, conveyors, etc., in its new concentration plant. R. F. Helm, Oklahoma, Supt.

Okla., Stillwater—The city will receive bids until Aug. 12 for a generator, boiler, switchboard and regulator. H. A. Pressey, City Hall, Oklahoma, Engr.

Colo., Frederick—The Rocky Mt. Fuel Co. plans to install a motor for the hoist in its new concentration plant.

N. M., Lordsburg—Cauthon and Connors plans to install complete air equipment to include power and compressors, etc., in their mine here.

N. M., Steins—The King and Queen Copper Mining Co. is in the market for complete power equipment, hoist; compressor, about 280 cu.ft. 20-hp. hoist, cable 400 ft., etc.

N. M., Steins—McGee Bros. will be in the market for a second-hand 600-ft. belt-driven compressor.

Ore., Portland—The Viking Marine Paint Co., Sherlock Bldg., plans to install motors, bitumen heating tanks, boilers, etc., in its proposed 1-story factory which is to be erected on Industrial Center. Rasmussen-Grace Co., 180 Burnside St., Engr.

Que., Montreal—The Imperial Tobacco Co., 900 St. Antoine St., plans to build an addition to its power house. Estimated cost, $10,000.

H. T., Pearl Harbor—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will receive bids until Aug. 12 for power house extension and improvement. Estimated cost, $150,000. A deposit of $20 is required for the plans and specifications.

CONTRACTS AWARDED

N. Y., Newark—A. W. Beaver, Pres. of the Board of Managers, New York State Custodial Asylum for Feeble Minded Women, has awarded the contract for the installation of a heating plant and equipment, to W. F. Devendorf & Co., 497 Court St., Rochester. Estimated cost, $31,500. Noted June 18.

N. Y., New York—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received low bids installing electric power system in structural shop, work complete, from United Electric Constr. Co., 101 Park Ave., $21,490—85 days; Watson Flag Engineering Co., 120 Liberty St., $23,349—90 days; Jandus Electric Engineering Co., 109 West 31st St., $22,900—80 days. Noted July 9.

N. Y., New York—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received low bids furnishing 4 switching locomotives, delivery U. S. Naval Fleet Base, from Baldwin Locomotive Works, Broad and Spring Garden St., Philadelphia, Penn., $22,650 (each); Lima Locomotive Works, South Main St., Lima, O., $18,010; H. K. Porter Co., Union Bank Bldg., Pittsburgh, Penn., $20,030; Vulcan Iron Works, Wilkes-Barre, Penn., $22,000.

N. Y., Rochester—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids furnishing 16 motors, delivery Optical Shop Annex, U. S. Naval Gun factory, from Eck Dynamo & Motor Co., Main St., Belleville, N. J., $301 (each); Electric Dynamo Co., Ave. A., Bayonne, N. J., $346; Imperial Electric Co., Ira Ave., Akron, O., $348; General Electric Co., River Rd., Schenectady, N. Y., $460; Ideal Electric Co., 153 East 5th St., Mansfield, O., $460; Fidelity Electric Co., 331 North Arch St., Lancaster, Pa., $290; Mechanical Appliance Co., 133 Stewart St., Milwaukee, Wis., $393; Robbins & Meyers Co., Lagonda Ave. and Farlow St., Springfield, O., $314; Roth Bros. & Co., 1400 North Adams St., Chicago, Ill., $309, alternate, $329; Northwestern Manufacturing Co., 480 Clinton St., $296; W. E. Tuttle, Jr., Garwood, N. J., $395; Triumph Electric Co., South St., Cincinnati, O., $334; Burke Electric Co., 12th and Cranberry St., Erie, Pa., $475; Westinghouse Electric Co., Hibbs Bldg., Wash., D. C., $265.

D. C., Wash.—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received low bids for 54 motors, from: Burke Electric Co., 12th and Cranberry St., Erie, Pa., $6,798; Wagner Electric Manufacturing Co., 6400 Plymouth St., St. Louis, Mo.; $6,274; Westinghouse Electric and Manufacturing Co., Hibbs Bldg., Wash., D. C., $5993; Allis-Chalmers, West Allis St., Milwaukee, Wis., $6,138; Bell Electric Co., Garwood, N. J., $6,270; Carroll Electric Co., 714 12th St., Wash., D. C., $6,653; Century Electric Co., 19th and Pine St., St. Louis, Mo., $6,780; Fidelity Electric Co., 331 North Arch St., Lancaster, Pa., $5,983; Fairbanks Morse Co., 101 Light St., Baltimore, Md., $6,088; Howell Electric Motors Co., Howell, Michigan, $5,970; General Electric Co., River Rd., Schenectady, N. Y., $6,300; Ideal Electric Manufacturing Co., 153 East 5th St., Mansfield, O., $7,472; Kimble Electric Co., 534 North Western St., Chicago, Ill., (part bid) $4,192; Lincoln Electric Co., Woodward Bldg., Wash., D. C., $6,537; MacGovern & Co., 114 Liberty St., New York City, N. Y., (part bid), $2,475; and $2,575; Mechanical Appliance Co., 133 Stewart St., Milwaukee, Wis., $7,351; Northwestern Manufacturing Co., 480 Clinton St., Milwaukee, Wis., $6,358; National Electrical Supply Co., 1330 New York Ave., Wash., D. C., $6,791; Phoenix Electric Co., Mansfield, O., $6,268; Robbins and Meyers Co., Lagonda Ave. and Farlow St., Springfield, O., $7,468 and $5,680; Roth Bros., 1400 West Adams St., Chicago, Ill., $6,268; Triumph Electric Co., South St., Oakley St., Cincinnati, O., $6,521.

D. C., Wash.—The Bureau of Yards and Docks, Navy Dept. has awarded the contract for 10 turbo generating sets and 200 K.V.A., to Moore Steam Turbine Corporation, Trade Bldg., Philadelphia, Pa., $81,370. Furnishing one 24 hp. AC. 220 volt, 3 phase, 25 cycl. 1200 r.p.m. motor, to Lincoln Electric Co., Woodward Bldg., Wash., D. C., $548. Furnishing three 15-hp. electric motors, to General Electric Co., River Rd., Schenectady, N. Y., $1095. Noted July 9.

D. C., Wash—The Bureau of Yards and Docks, Navy Dept., received low bids furnishing 4 torpedo electrically driven air compressors, and 2 sets of spar parts, from Ingersoll-Rand Co., 11 Bway., New York, N. Y., $46,909; Flat Iron Works, Dayton, Ohio, $48,155.

Colo., Brush—The Board of Education has awarded the contract for a heating plant to be installed in the proposed 3-story school, to City Heating and Plumbing Co., Boulder. Estimated cost; $11,000.

Colo., Denver—Swift & Co., Denver Union Stockyards, has awarded the contract for an addition to its boiler house, in connection with the new 4-story building, to F. Kirchof Lumber Co., 1215 7th St.

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current
Buckwheat	$3.40
Rice	2.90
Boiler	2.65
Barley	2.40

All-rail rate to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual
Pea	$5.20	$5.95
Buckwheat	5.15	5.90
Rice	4.65	5.10
Barley	4.15	4.30
Boiler	4.60	....
Broken	6.75	7.50
Egg	6.35	7.10
Stove	6.60	7.35
Chestnut	6.70	7.45

Quotations for domestic coals at the upper ports are 5c. higher on account of the difference in freight rates. Prices for buckwheat, rice, barley and boiler are not fixed by the Government.

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b., Tidewater, at the lower ports, are as follows:

	Mine	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)		$3.30 $5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports are 5c. higher on account of the difference in freight rates.

The foregoing prices ar exclusive of the 3 per cent. war freight tax on both anthracite and bituminous.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The ratte to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$3.45	$3.10	$4.60	$4.00
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.80
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

	Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70		$3.25—3.40
Mine-run	2.35—2.50		3.00—3.15
Screenings	2.05—2.20		2.75—2.90

St. Louis—Prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Mt. Olive & Staunton	Standard
6-in. lump	$2.55-2.70	$2.55-2.70	$2.40@2.70
2-in. lump	2.55-2.70	2.55-2.70	2.40@2.70
Steam egg	.....	.....	2.40@2.70
Mine-run	2.35-2.50	2.35-2.50	1.85@2.00
No. 1 nut	2.55-2.70	2.55-2.70	....
2-in. screen	2.05-2.20	2.05-2.20	....
No. 5 washed	2.05-2.20	2.05-2.20	1.25@1.50

Williamson-Franklin rate to St. Louis is $1.10, other rates, $0.95.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam	$2.50	$2.80	$2.20
Cahaba, Black Creek, Brookwood, Blue Creek	3.20	3.45	2.80
Pratt, Jaeger, Jefferson Nickel Plate	2.70	3.00	2.40
Corona	2.75	3.10	2.40

The above are Government prices per net ton of 2000 lb. mines and include the 45c. per ton allowed by the wage agreement, less 10c. reduction which was effective May 25, as a result of the agreement with the railroad administration for furnishing fuel coal.